Technical Report
Some Technical Aspects on Midwater Trawl Operations Lesson learnt from the Operation of M.V.SEAFDEC2 around Viet Nam Waters

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1. Introduction

Midwater trawl in Southeast Asian countries, however, has not been implemented by both small scale and commercial scale private sector because the small pelagic resource has been harvested mainly by purse seine and gillnet. Fisher has familiarized and skillful on such fishing gear and practices than midwater trawling. It is also midwater trawl requires sophisticate and high technology of fishing finding instruments, e.g. scanning sonar, net sensors to searching and locating fish schools that local fishers have not been interested in such fishing practice. Midwater trawl, however, is one of the important fishing-sampling gear installed onboard M.V.SEAFDEC2. Target of midwater trawl fishing operation is to investigate the distribution and abundance of small pelagic resources e.g. Indo-Pacific mackerel, scad, sardine, and etc. Opposite on the commercial fisheries, small pelagic fisheries resources research survey has not effectively investigated by purse seine or gillnet. Calculation on *Catch Per Unit Effort* (CPUE) conducted by purse seine or gillnet is not well precision compare with conduct by trawl. Midwater trawl for estimating the abundance of pelagic fisheries resources is undertaken by similar standard methodology as bottom trawl. CPUE could possibly to investigate by weight/time, e.g. kg/hr, and etc. Abundance could also possibly to calculate by weight/pathway in distance, or even volume of seawater through net opening. By this reason, methodology to estimate the abundance of small pelagic fisheries resources including with stock assessment through Hydroacoustic equipment (Scientific Echo Sounder) is applicable to used associated with landing catch survey. In order to confirm fish species detected by Hydroacoustic equipment, midwater trawl is significant fishing gear, suitable to concurrently operate during acoustic research survey on pelagic fisheries resources.

M.V. SEAFDEC2 is a research vessel constructed under supported by Japanese Government in 2004. The main purpose is to support SEAFDEC Member Countries on fisheries resources research survey and training on various kind of fishing technologies, e.g. trawl, longline, gillnet and squid jigging. M.V. SEAFDEC2, however, has not operated midwater trawl since 2004. Mostly of demersal resources research surveys are carried out by using bottom trawl and large pelagic resources by using pelagic longline. Only few operations are conducted during crew training at Andaman Sea in early of year 2005. Therefore experience and skill of crew members on fishing gear and practices of midwater trawl has very less.

In year 2012, Department of Fisheries, Viet Nam requests to SEAFDEC using M.V.SEAFDEC2 for national pelagic resources research program. Midwater trawl is principle fishing gear to collect small pelagic fish sample of the cruise. Although result of fishing operations are not fully satisfied regarding to less experience and skill of crew members on midwater trawl operation, including with fishing accessories e.g. net sensors, towing warp counter and net winch is not well function, the information on fishing techniques is very important to develop midwater trawling technology for SEAFDEC crew and other who is interested in the future.

2. Objective

To present information of midwater trawl fishing operation in different criteria for improving midwater trawl fishing technology and practices

3. Research Methodology

3.1 Material

a) M.V.SEAFDEC2 included with fishing finding system and deck machineries for trawling (see appendix 3)

b) Midwater trawl net (see part 5)

c) Depth loggers Brand name ReefNet™ Model Sensus Ultra

d) Net Sonde Furuno™ Model FNZ-40 with receiver and display

(a) (b)

Figure 1 (a) Depth loggers Brand name ReefNet™ Model Sensus Ultra

(b) Net Sonde Furuno™ Model FNZ-40 with receiver and display

3.2 Method

a) Review secondary data is method to obtain basic information of midwater trawl install onboard M.V.SEAFDEC2 . Report of Fishing gear inventories published by Taito Seiko Fishing Company, Japan, is described construction and fishing operation of M.V. SEAFDEC2.

Fishing gear handbooks (1990) published by Food and Agriculture Organization (FAO) and fact sheet on webpage of FAO-Fisheries is key reference to understand midwater trawling of the world.

b) Ten (10) Fishing operation including with 2 sea trial operations of Midwater trawl are conducted around Viet Nam Waters during June-July 2012. Information of midwater trawl net is emphasized on (1) depth of capture, (2) net opening and fishing operations in related with different criteria e.g. current condition, fishing gear structures by using kite and without kite.

All fishing operation, net sonde Furuno FNZ-40 has fitted at center of head line. Three (3) sets of depth loggers are fitted with head line, fishing line and otter board.

4. Area of Operation

The operations are conducted Central part of Viet Nam Waters, South China Sea. Twelve (12) midwater trawl fishing operations, including with one (1) sea trial, are operated from station 11 to station 27. Midwater trawl fishing positions are shown by triangle symbol (▲) at figure 2.

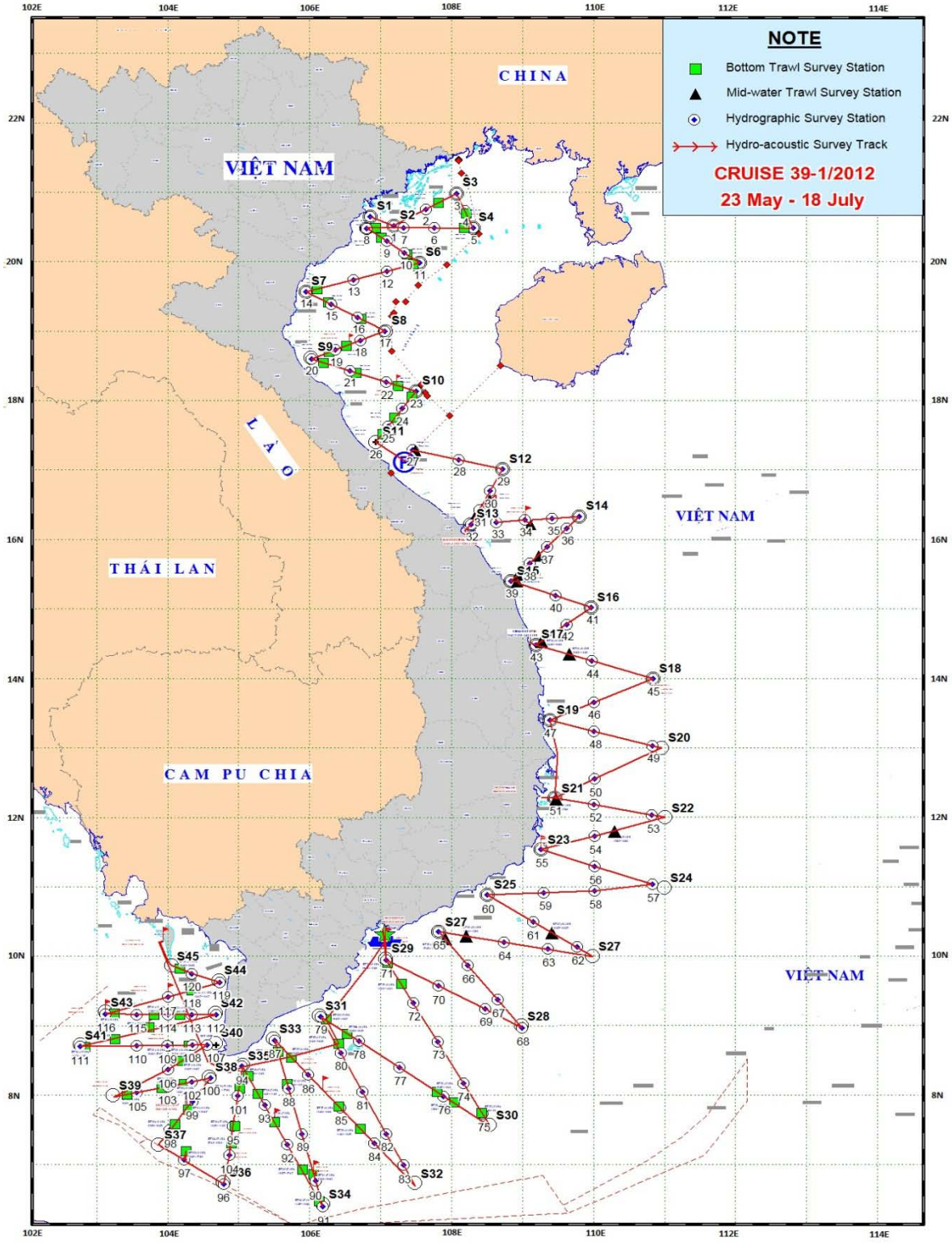


Figure 2 Area of Operation around Central part of Viet Nam Waters, South China Sea
Source: Tentative cruise report of M.V. SEAFDEC2 No. 39-1/2012

5. Result

5.1 Review the Definition and classification of midwater trawl

Midwater trawl are a type of trawl net, operated by dragging or towing the flexible net through the water by fishing vessel, to catch pelagic fish in the middle layer (middle layer means the water layer in between the first few meter below the surface and the first few meter above the sea bed). Usually midwater trawl is carried out on the deep sea fishing ground. (SEAFDEC, 2005)

FAO (2012) explains general structure of midwater trawl, consists of a cone shaped body, normally made of four panels, ending in a codend with lateral wings extending forward from the opening. It is usually much larger than a bottom trawl and designed and rigged to fish in midwater, including in the surface water. The front net parts are sometimes made with very large meshes or ropes, which herd the targeted fish inwards so that they can be overtaken by smaller meshes in the aft trawl sections. The horizontal opening is maintained either by otterboards or by towing the net by two boats (pair trawling). Floats on the headline and weights on the ground rope often maintain the vertical opening. Modern large midwater trawls, however, are rigged in such a way that floats are not required, relying on downward forces from weights to keep the vertical opening during fishing. Midwater trawl is classified into 2 types, i.e. 1) A Midwater ottertrawl and 2) Midwater pair trawl

(1) Midwater otter trawl

A midwater otter trawl is a type of trawl net, cone-shaped design which is towed in midwater. It consists of a cone-shaped body, normally made of four panels, ending in a codend and the net has lateral wings extending forward from the opening. The horizontal opening is maintained by otter boards. Floats and/or sail-kites on the headline and weights on the fishing line (or ground line) provide for the vertical opening. Large modern midwater trawls are rigged in such a way that the weights in front of and along the fishing line provide for the vertical opening of the trawl. The cable transmitting acoustic signal form the net sonde or net sensors might also provide a lifting force that maximizes the vertical trawl opening. To reduce the resistance of the gear and achieve a large opening, the front part of the trawls is usually made by very large rhombic or hexagonal meshes. The use of nearly parallel ropes instead of meshes in the front part is also a common design. The largest mesh sizes used so far are 128 m and, on modern large midwater trawls, approximately three quarters of the length of the trawl is made with mesh sizes above 400 mm.

(2) Midwater pair trawl

A midwater pair trawl has roughly similar design as other midwater trawls. Midwater pair trawls might, however, be designed to have a more rectangular opening than ordinary midwater otter trawls. Midwater pair trawls might be rigged with two towing warps from each vessel or alternatively with one towing warp from each vessel and a bridle arrangement. One of the advantages of pair trawling is the possibility to tow the trawl very

close to the surface. Herding effect on fish by the two vessels may increase the capture efficiency in shallow waters and at the surface. http://www.fao.org/fishery/topic/1617/en

5.2 Midwater trawl net construction and design of M.V.SEAFDEC2

Midwater trawl net what installed with M.V. SEAFDECs is manufactured by Taito Seiko Fishing Company, Japan. Trawl net is structured by four (4) net seams with head rope and fishing rope (or ground line) is equaled as 42.3 m. Left and right wing line (side seam) is 34.8 m. Total circumference of net mouth is 154.2 m. Length from wing net to codend part is approximately 88 m. Head rope is assembles with canvas kite, area is 5.3 square meter and fishing rope is assembles with chain diameter 19 mm. Trawl net is separted into parts, i.e.

1) Net body is 87.91 m length overall. Net is composed with 3 main parts i.e.

1.1) Opening part (or net mouth) is composed with various big mesh size 10 m, 8.7m, 7.5 m., 6.5 m., 5.6 m., 4.8 m. Each mesh size has a mesh depth with hanging ratio (E) approximately 0.97. Total length is 41.33 m.

1.2) Net body part is Polyethylene 360 denier material. Net composed with 9 sections. Twin size is composed with 630 ply, 360 ply, 324 ply, 216 ply, 180 ply, 135 ply, 90 ply and 180 ply. Total length is 40.76 m.

1.3) Cod end part is only portion made by Polyethylene 360 denier and twine size is 360 ply. Mesh size 60 mm. Total length is 5.82 m. Two (2) cover net sheets (upper and Lower) is Polyethylene 360 denier and twine size is 360 ply. Mesh size 60 mm.

Figure 3 Midwater trawl net

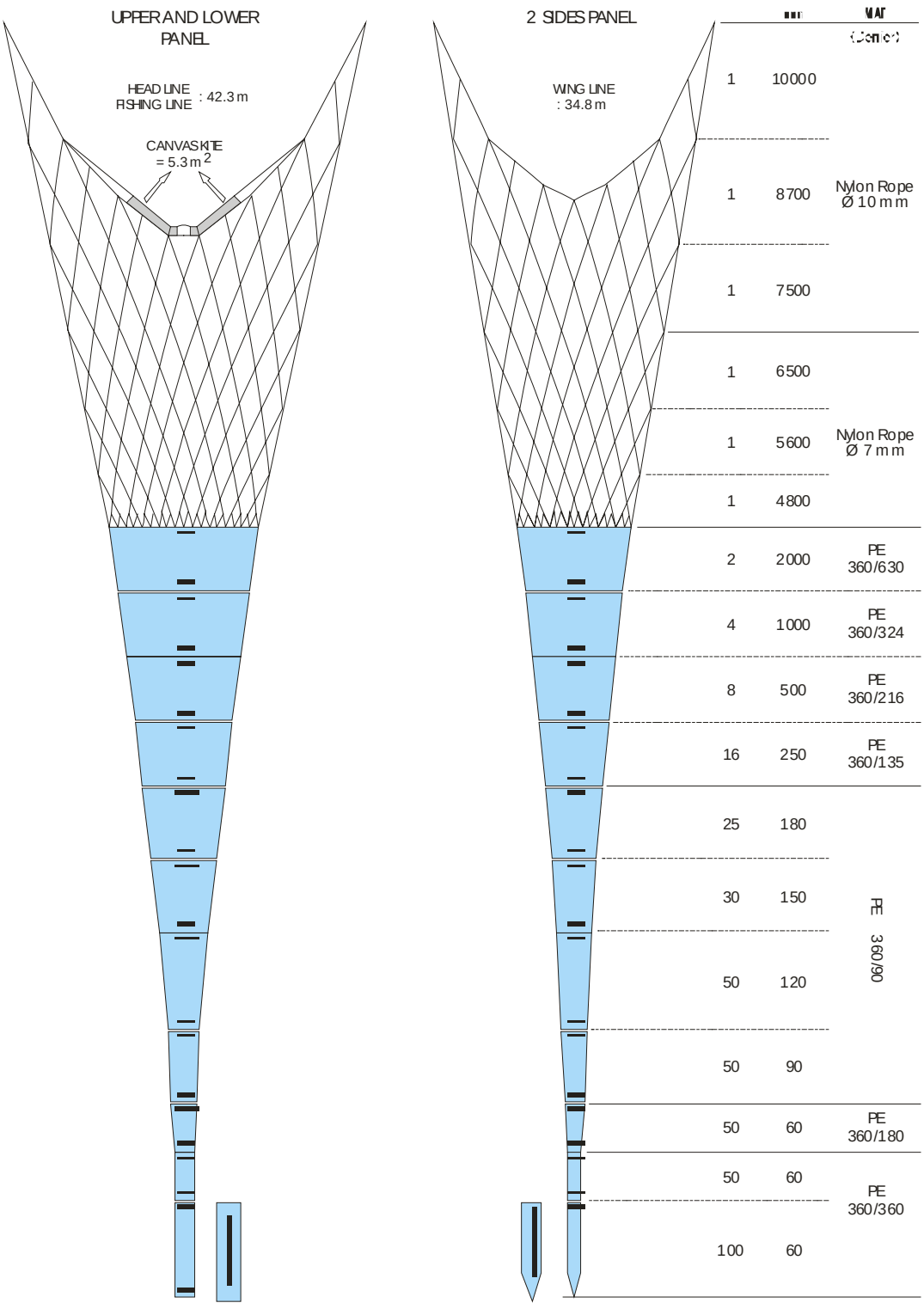


Figure 4 Midwater trawl net design

2) Canvas Kite

Canvas kite is used for add the lifting power of midwater trawl. It is very useful to operate nearby sea surface or shallow water area. Total area of kite is 5.3 square meter. It is assemble with 2 Nylon canvass sheets. Each sheet is fixed at left upper bosom-wing and right upper bosom- wing (see figure). They are joined together by iron chain (long-pitch) diameter 12.5 mm, 19 links. Total chain length is 0.87 m. Each nylon canvas is composed with 2 rectangular nylon sheets, size 4.65 x 0.65 m and 0.4 x 0.65 m. (see figure), and it is framed by iron wire, diameter 12 mm.

(a) (b)

Figure 5 (a) Midwater trawl net with canvas (b) Midwater trawl net without canvas

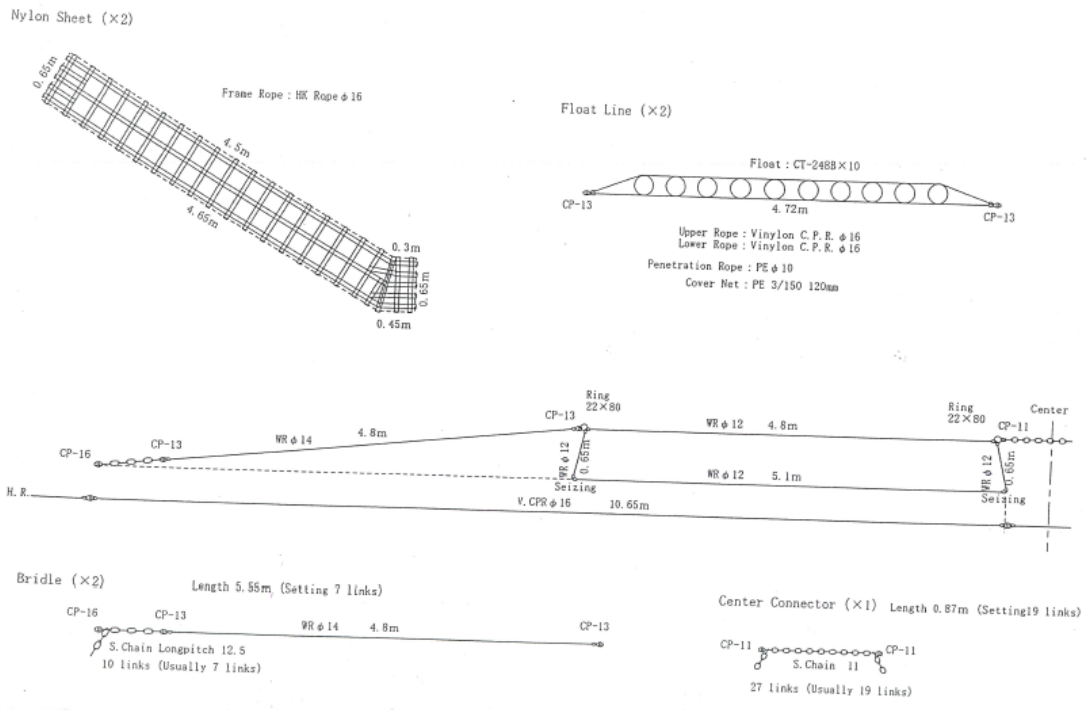


Figure 6 Canvas Kite construction and design for vessel 1000PS engine

3) Additional set of floats

a) Additional set of floats attach with head line.

In order to obtain higher lifting force, two set of additional floats is required to assemble at head line, on top of the kite. Each set of additional floats is composed with 10 ABS-floats, size 24 cm diameter (Commercial code CB-248B). Each float is buoyancy 6.2 kgf. Total of all additional set of floats are 124 kgf. Each set of ten floats are fixed by 2 Vinylon Compound Rope (CPR) diameter 16 mm, and covered by PE nylon net sheet.

b) Additional set of floats attach with net pendants.

Additional lifting force is also attached with, each side of net pendants. Each set of additional floats is composed with five (5) ABS-floats (Code. CB-368B), diameter is 360 mm. Each float is 31.0 kg buoyancy force. Total of both additional sets of floats are 310 kgf. Each set of five floats are fixed by two (2) pieces of Vinylon Compound Rope, diameter 16 mm.

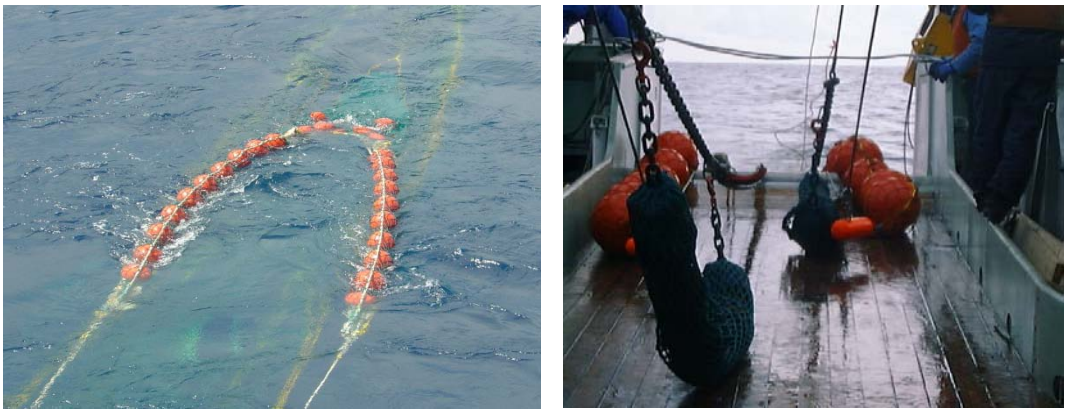


Figure 7 (a) Additional set of floats attach with head line (b) Additional set of floats attach with net pendants

4) Sinker

a) Iron chain fixed with ground rope.

Material of sinker of trawl net is iron chain size 19 mm diameter. Total length of chain is 42.3 m. Weight of chain is 7 kg/m, Total weight assemble with ground rope is approximately 306 kg.

b) Additional weight fix with net pendants.

There are 2 set of additional weight, worm-liked shape. They made by combination material, i.e. iron chain, iron sinkers and pieces of punch tire. Iron chain is

diameter 19 mm. 2.5 m, length. Iron weight is 5 kg/piece, 8 pieces. Punch tire diameter 150 mm, 80 pieces. Total weight is approximately 80 kg/set.

Figure 8 Additional weight fix with net pendants

5) Towing warp and net pendants

Set of towing line is composed with net pendants (4 lines), hand rope (2 line) and otter board pendants (4 lines) and sweep line (2). Their constructions are described as below;

a) Towing warp is main towing line, composed with 2 lines left and right warp. Construction is iron wire, structure 6x19, diameter is 20 mm, 1500 m in length of each towing warp. It is possible for fishing depth around 300 m.

b) Otter board pendants are the lines join between otter board and hand rope. It is composed with 2 iron wire, upper pendent and lower pendent. Both wires are the same structure, 6x26 diameter 18 mm, length 8 m.

c) Hand rope is a line join between otter board pendant and net pendant. There are 2 lines left and right. Hand rope is iron wire, structure 6x26 diameter 20 mm, 15 m in length.

d) Net pendants are the lines connect between wings part of trawl net and hand ropes. It is composed with 2 pieces of wires, upper pendent and lower pendent, with different structure. Upper pendant is wire is structured, 6x26 diameter 14 mm, length 47 m, 2 pieces (total length is 94 m). Lower pendant is wire is structured, 6x26 diameter 16 mm, length 47 m, 2 pieces (total length is 94 m).

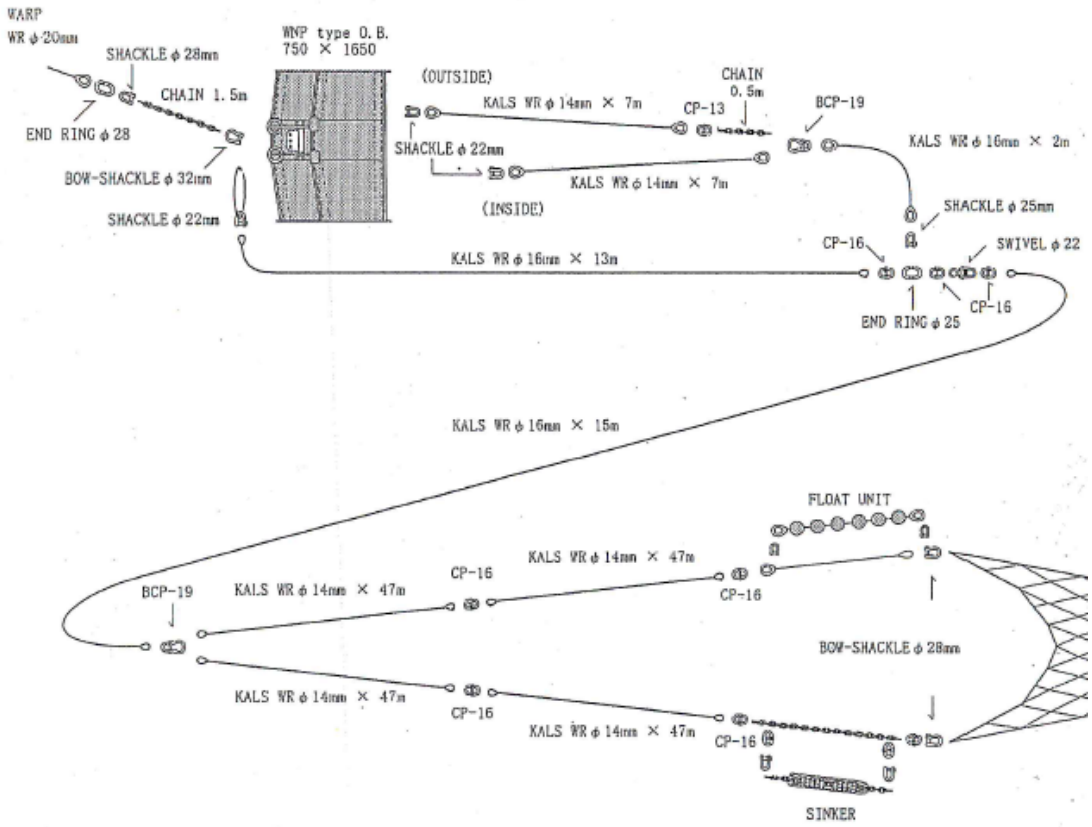


Figure 9 Set of standard otterboard pendant, sweep line and net pendent

6) Otter boards

Otter board of midwater trawl of MV SEAFDEC2 is Biplane design. The design is standard design of Japanese midwater trawl. Its dimension is 1,650 mm in height and 750 mm in length with double vertical boards. Weight in air of otter board body is 402.5 kg and weight in water is 350 kg.

There are six (6) iron plates, assembled as additional weight. Each plate is 25 kg. Total weight in air of otter board body with additional weight is 574.7 kg and weight in water is 500 kg. Attacked angle is from 19 to 34 degree depended on otter board pendant setting.

Pelagic otter board adjustment for the reference

a. Normally attack angle should be kept between 20-25 degree if otter board spread too much (Less net resistance), the attack angle should be kept at 10 degree. If it is the opposite, the attack angle should be kept at 30 degree.

b. The attack angle should be fixed by adjust the length of outside otter board pendant as show in figure.

c. 10 degree of attack angle use CP13+chain 2 rings+CP16

20 degree of attack angle use CP13+chain 1 rings+CP16

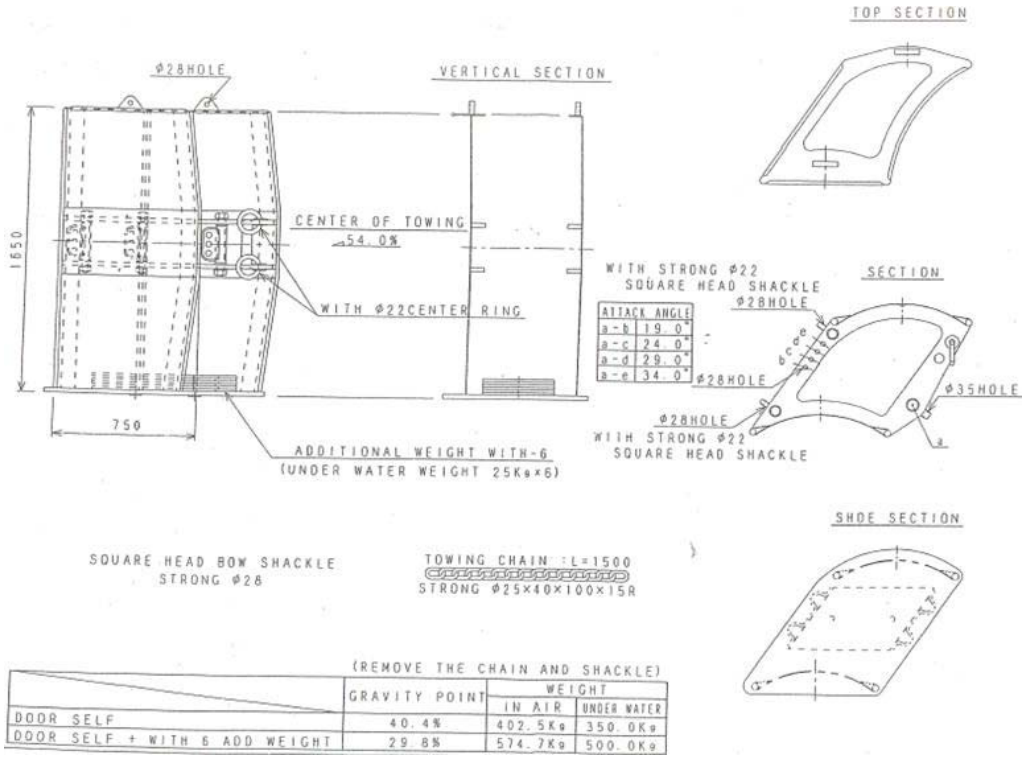
30 degree of attack angle use CP13+CP16

25 degree of attack angle use only CP16

The above CP13, CP16 and chain are connected with one line therefore it should be manually fixed. (See figure)

d. Attack angle is also adjusted by using otter board hole (5 holes). Bot it is recommended to use outside otter board pendant.

e. Weight of otter board should be 220-245 kgs but when the net is towed in a very shallow water, it may be adjusted by taking off additional weight.



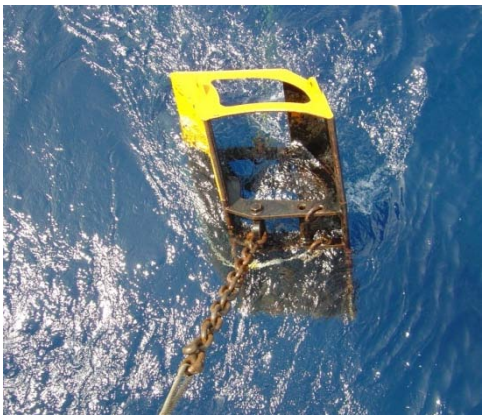
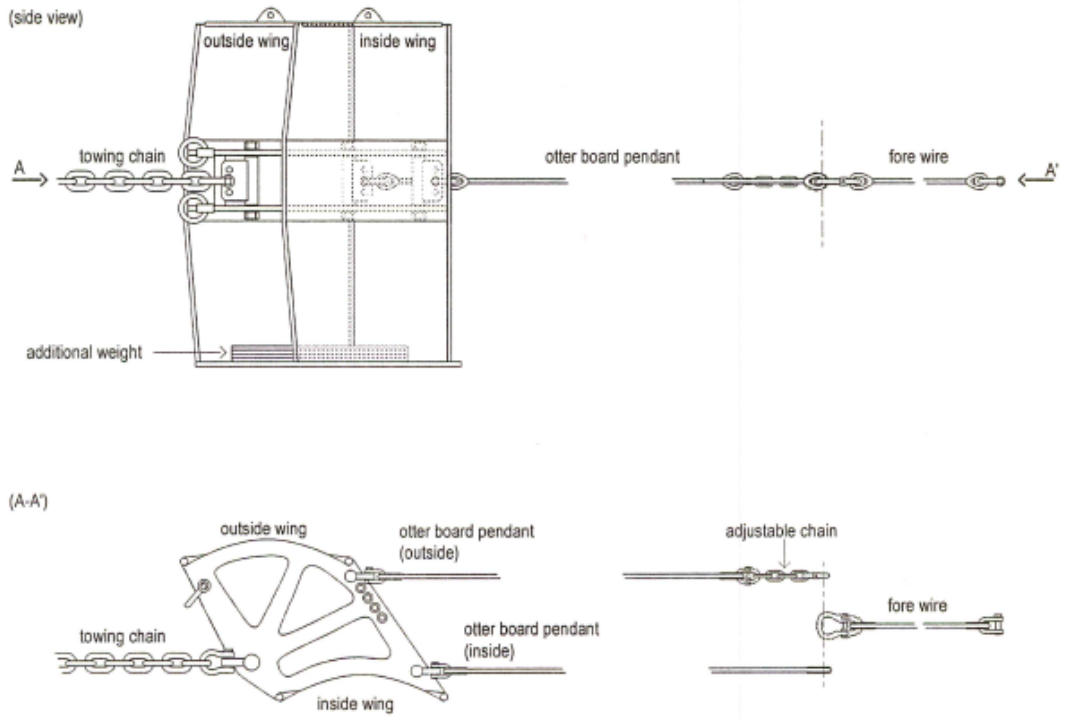


Figure 10 Bi-plane otter board construction and design for vessel 1000PS engine



adjustment of weight

	in air	under water
door self	402.5 kg	350.0 kg
door + additional weight 1	431.2 kg	375.0 kg
door + additional weight 2	459.9 kg	400.0 kg
door + additional weight 3	488.6 kg	425.0 kg
door + additional weight 4	517.3 kg	450.0 kg
door + additional weight 5	546.0 kg	475.0 kg
door + additional weight 6	574.7 kg	500.0 kg

excluding towing chain and metal fittings

adjustment of attack angle

otter board pendant (outside)	attack angle (estimated)
CP13 + chain 4 ring + CP16	out of use
CP13 + chain 3 ring + CP16	out of use
CP13 + chain 2 ring + CP16	10 deg.
CP13 + chain 1 ring + CP16	20 deg.
CP13 + CP16	25 deg. (recommended)
CP16	30 deg.
	out of use

Figure 11 Bi-plane otter board adjustment

5.3 Midwater trawl operational procedure

5.3.1 Preparation for fishing operation

a) Wind up each wire onto the trawl winch, hang up otter boards at gallows after connecting the otter board pendant and roll up the trawl net pendant, hand rope and free wire onto net winch.

b) Fold the trawl net on the deck from the cod end to the middle part of headline in front of slip way, leave space to fitting with net sensors and also fold net wing on the deck

c) Hook band ropes of the cod end by the net shooting hook, lead wire of net shooting hook to a capstan winch through the center hanging block and fix up net sensors on design positing of head rope center. Fasten front float and weight to the net pendants nearest to the wing part.

d) Adjustment otter board to proper position

5.3.2 Shooting operation

a) The vessel go slow ahead (2-3 knot) preferable engine control is 870 rpm, pitch 3-4.

b) According to the instruction of fishing master, start the fishing operation by shooting con end into the sea by winding up the wire of net shooting hook onto the capstan through the center of hanging snatch block.

c) Keep shooting the net until tension reach headline. Then release the hanging rope a little by a little until net sensors are into the sea.

d) Payout the net pendants and the hand rope by winding off the net winch while checking that there is not a tangle of the head line.

e) When the joint part of hand rope and the free wire come ojut on the deck, connect the otter board pendant wires to the joint part by a shackle and continue payout the free wires.

f) When all tension is on the otter board pendants, take off free wire from the wire rope of the net winch and hang up at otter board by a shackle.

g) After connecting the towing chain of otter boards to warp wires, wind up the warp wire slowly and detach the otter boards from the stopper hooks and prepare to shoot otter boards into the sea.

h) Speed up vessel to 7-8 knot and start shooting otter boards by winding off the trawl winch and gallows, keep monitoring shape and spread of otter boards.

i) Pay out the warp wire until the planned length, while keeping the spread of otter boards.

j) Stop paying out warp wire under the condition of planned water depth of net and tow the trawl net at speed 3.5-4.0 knot with underwater camera and 4.5-5.0 knot without it.

5.3.2 Hauling operation

a) Wind up each warp wire at speed 0-2 knot of vessel.

b) Hook up the towing chain by stopper hooks of the otter boards when otter boards come up at gallows and slacken the warp wire.

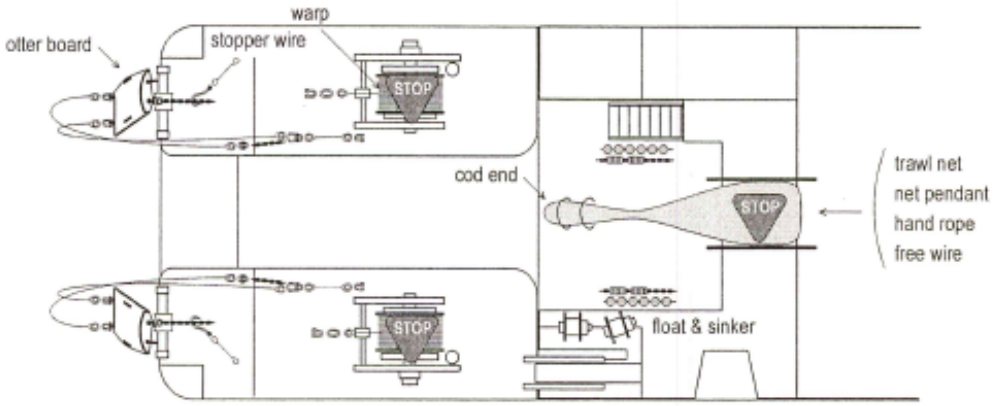
c) Taking off free wires from the otter boards and connect to wire rope of the net winch

d) Wire up each free wire onto net winch and tale off the otter board pendants when the joint part of otter board pendants and the hand rope come onto the deck.

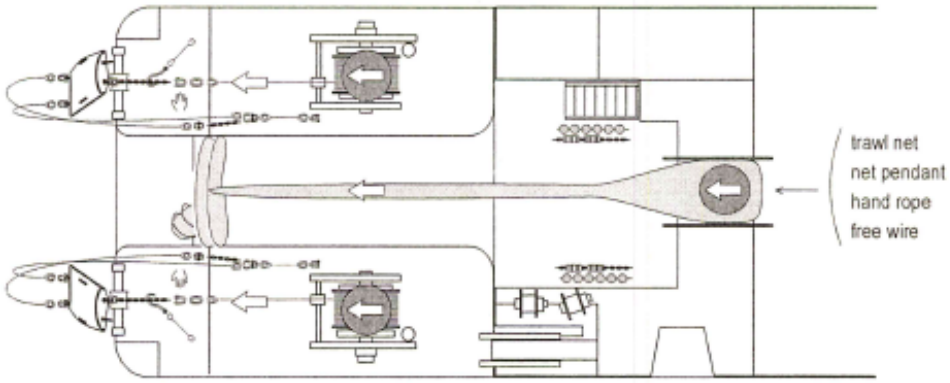
e) Winging hand rope, net pendants and the wing of trawl net. Remove all additional equipment e.g. underwater TV camera or net sensors when they come up on the deck.

f) Continue winding up the net up to cod end. Or hook up the cod end by the net hauling hook and haul it onto the deck.

- P-1 : STAND BY -



- P-2 : FOLDING TRAWL NET -



- P-3 : MOUNTING NET SENSOR and UNDERWATER TV CAMERA -

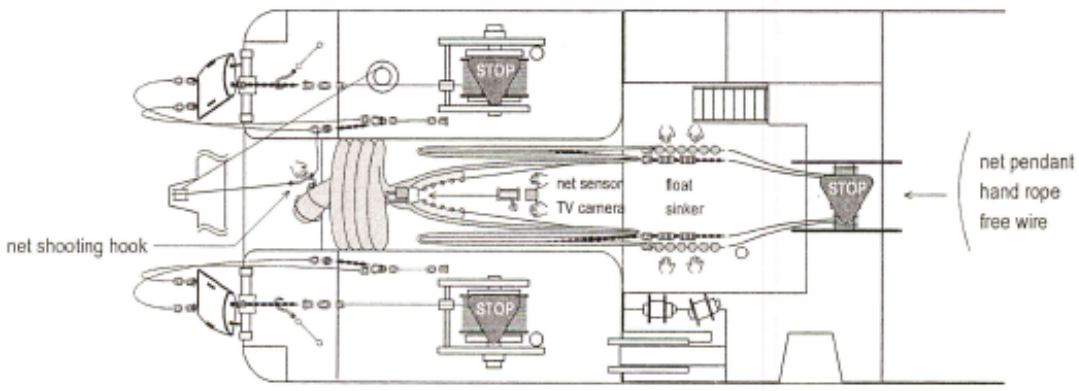
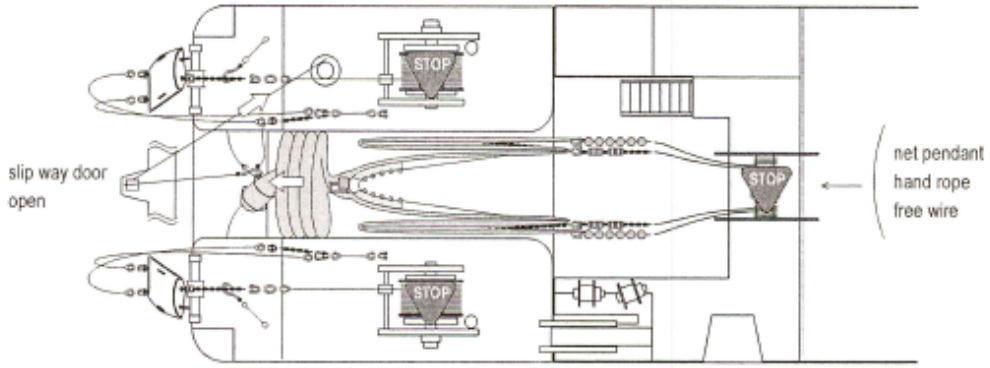
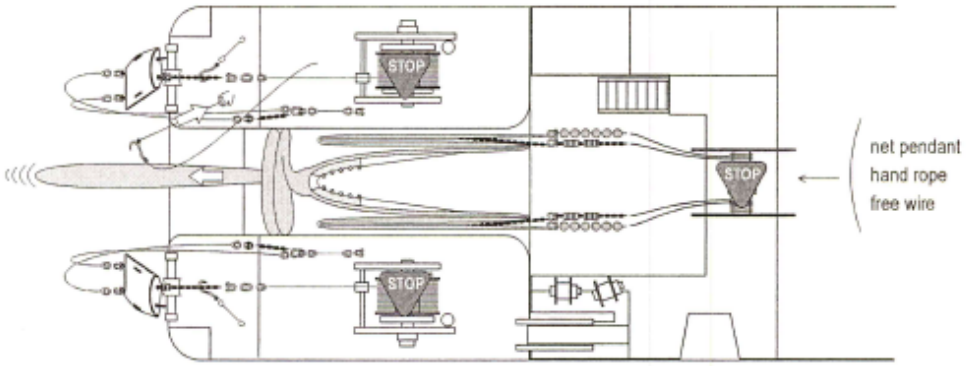


Figure 12 Net preparation procedure step 1, 2, 3

- S-1 : SHOOTING COD END -



- S-2 : SHOOTING NET -



- S-3 : SHOOTING HEAD LINE -

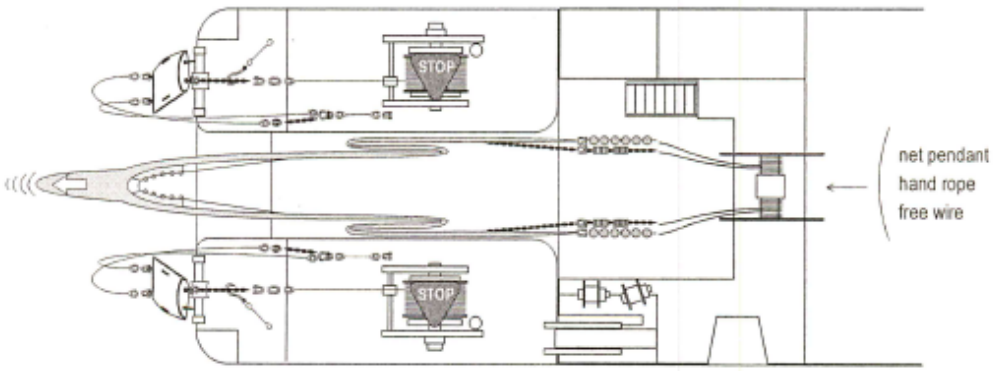
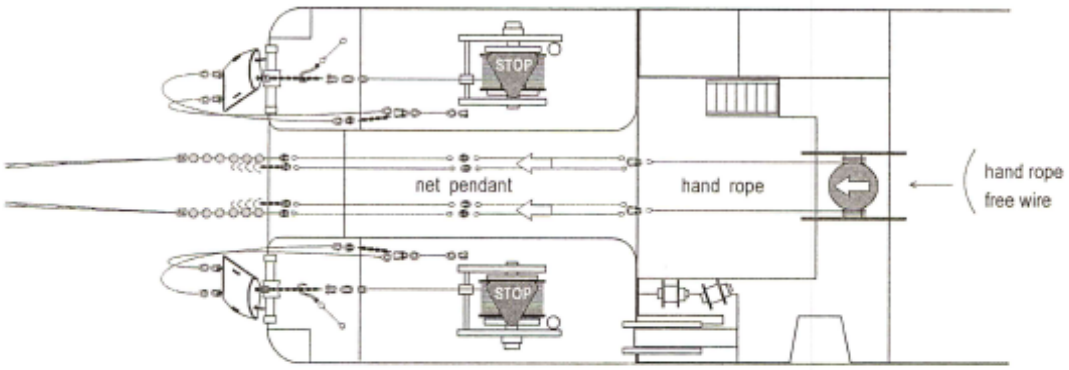
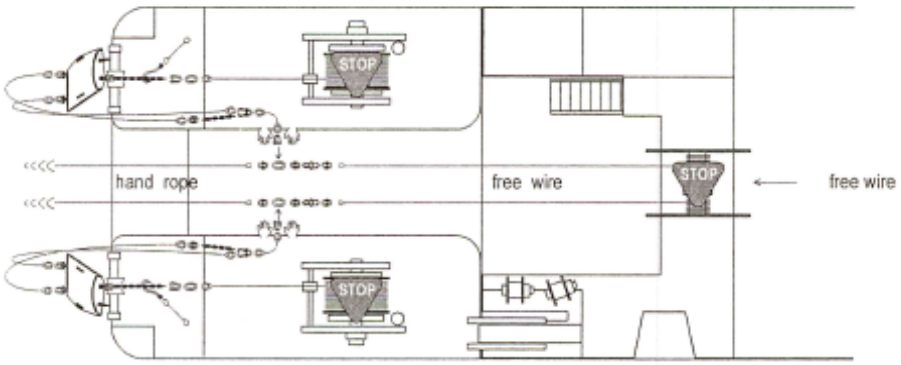


Figure 13 Shooting operation procedure step 1, 2, 3

- S-4 : PAYING OUT NET PENDANT & HAND ROPE-



- S-5 : COUPLING HAND ROPE & O.B. PENDANT -



- S-6 : PAYING OUT O.B. PENDANT to HANDROPE -

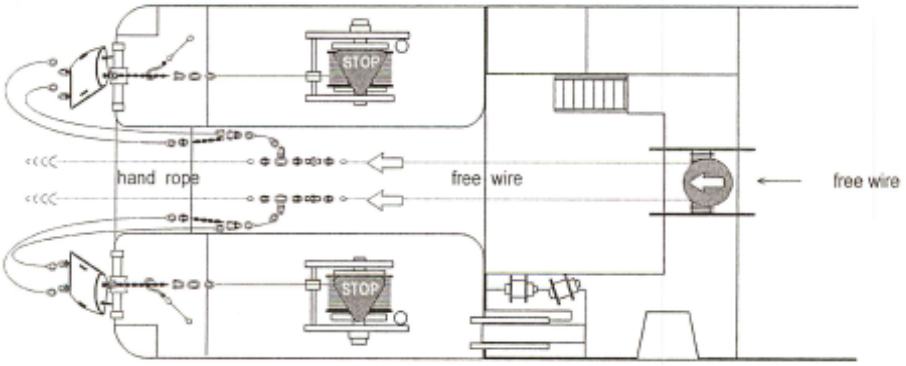


Figure 14 Shooting operation procedure step 4,5,6

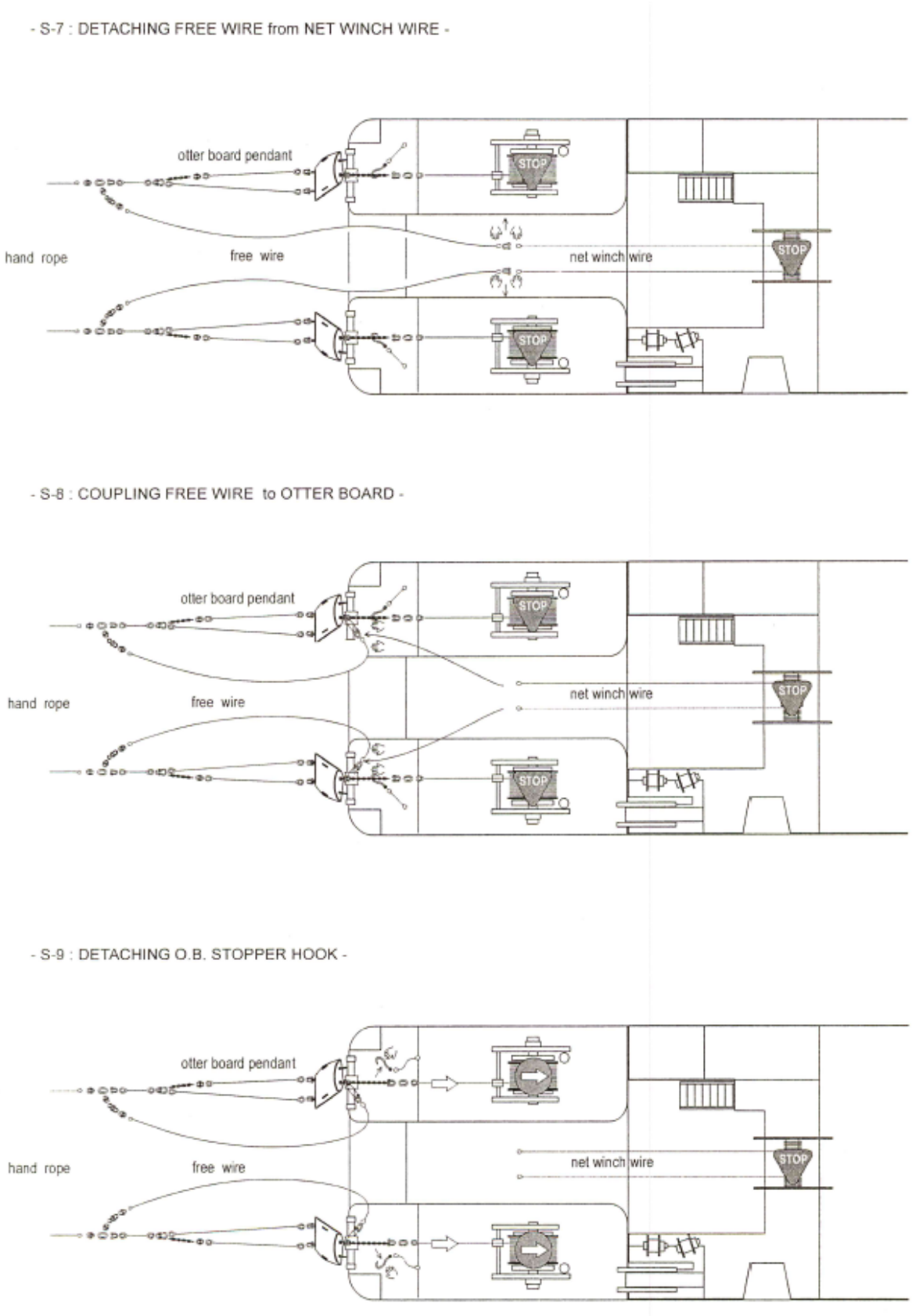


Figure 15 Shooting operation procedure step 7, 8, 9

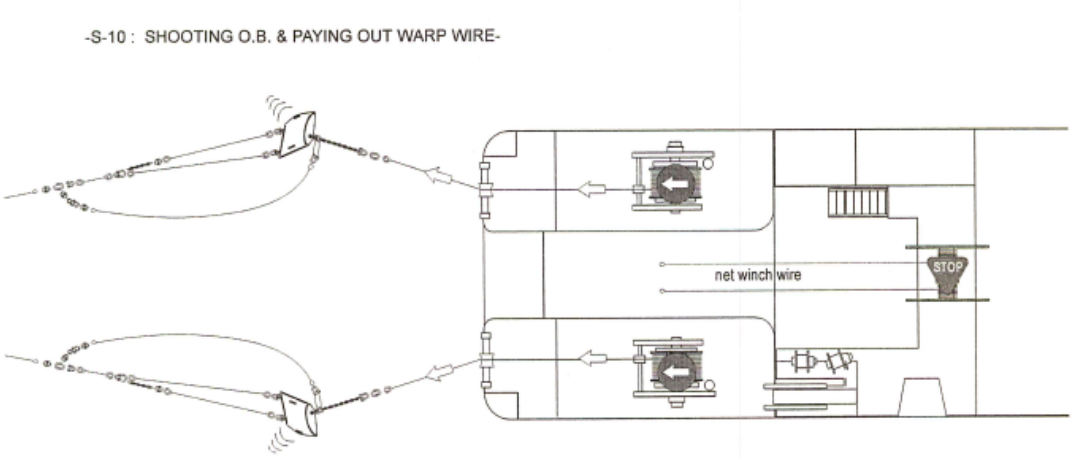


Figure 16 Shooting operation procedure step 10 (Finish fishing operation)

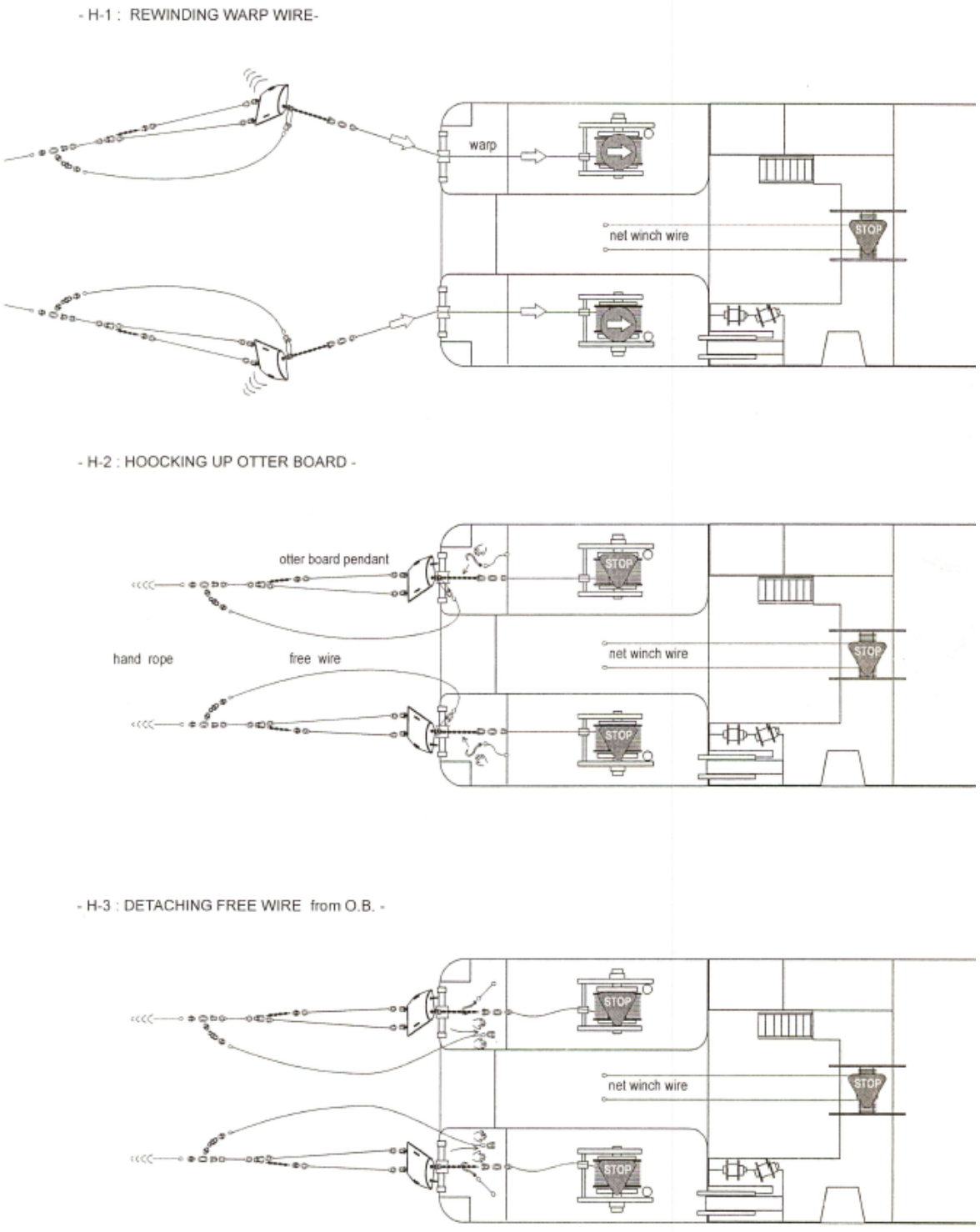
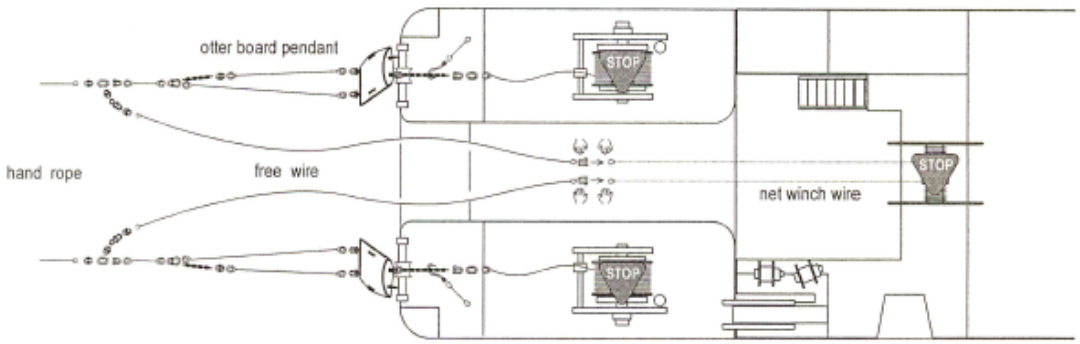
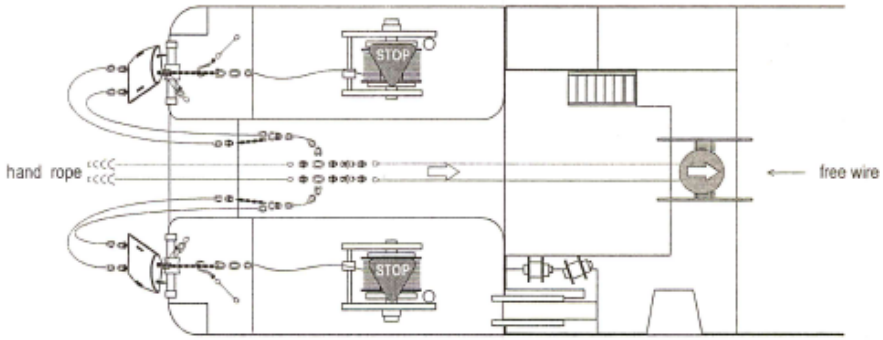


Figure 17 Hauling operation procedure step 1, 2, 3

- H-4 : COUPLING FREE WIRE to NET WINCH WIRE -



- H-5 : REWINDING FREE WIRE & O.B. PENDANT -



- H-6 : DETACHING O.B. PENDANT from HANDROPE -

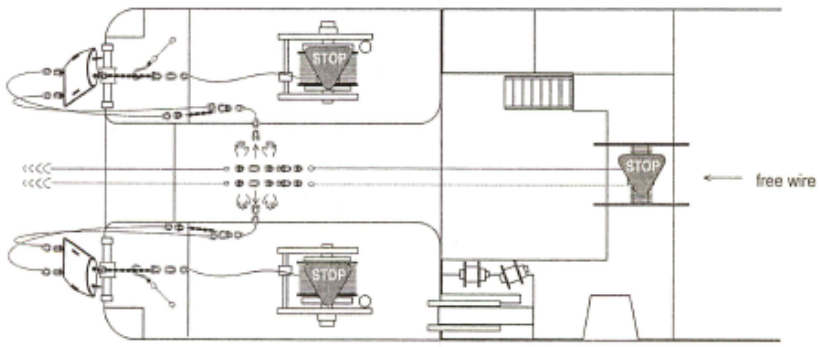
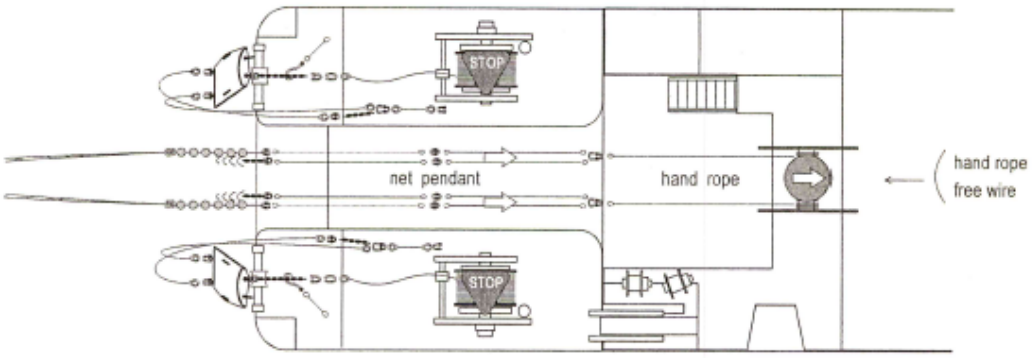
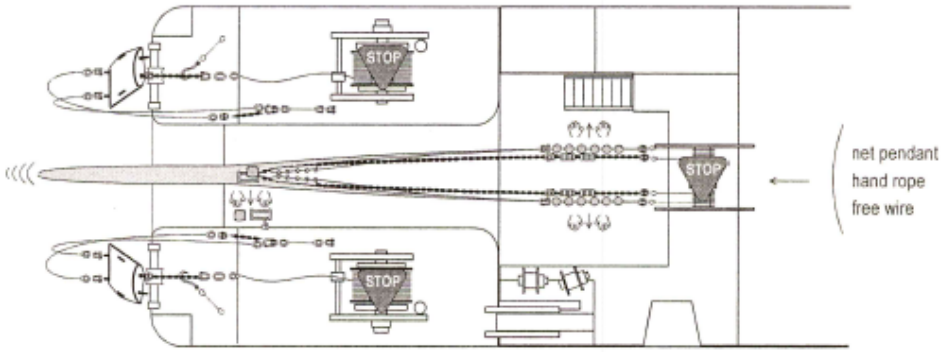


Figure 18 Hauling operation procedure step 4, 5, 6

- H-7 : REWINDING HAND ROPE & NET PENDNT-



- H-8 : UNMOUNTING NET SENSOR and UNDERWATER TV CAMERA -



- H-9 : HAULING NET -

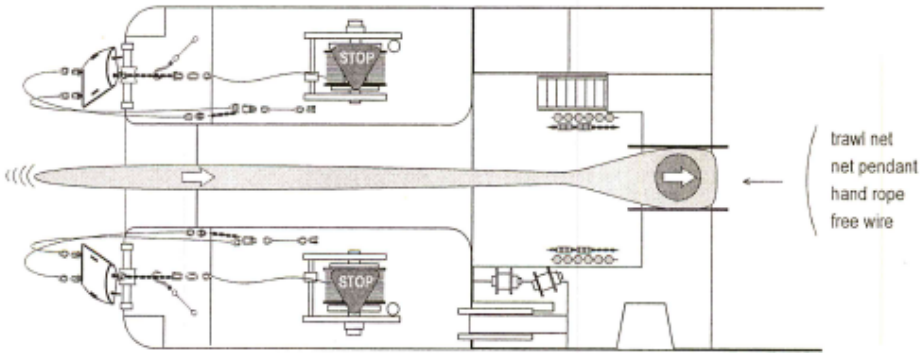
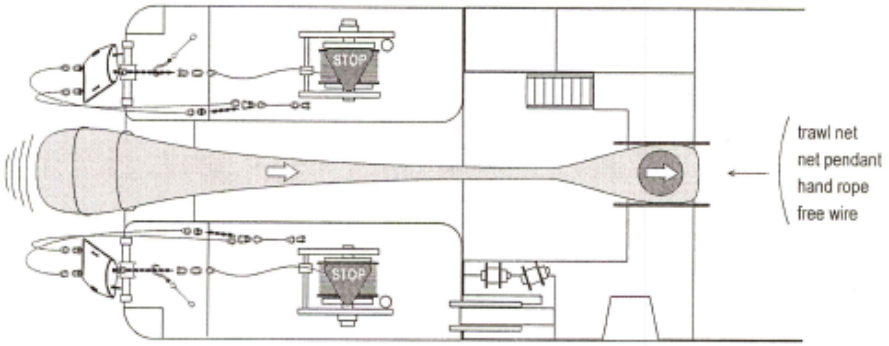
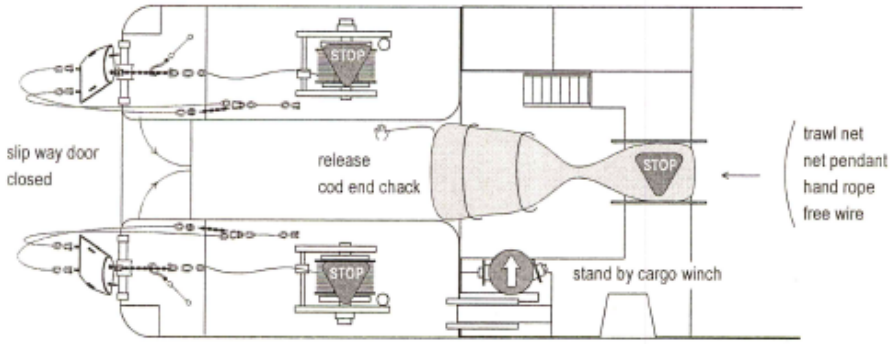


Figure 19 Hauling operation procedure step 7, 8, 9

- H-10 : HAULING COD END -



- H-11 : HAULING COD END -



- H-12 : HOISTING COD END -

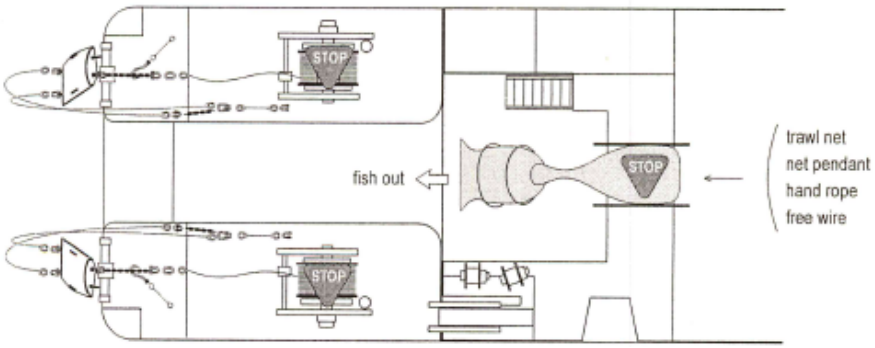


Figure 20 Hauling operation procedure step 10, 11, 12

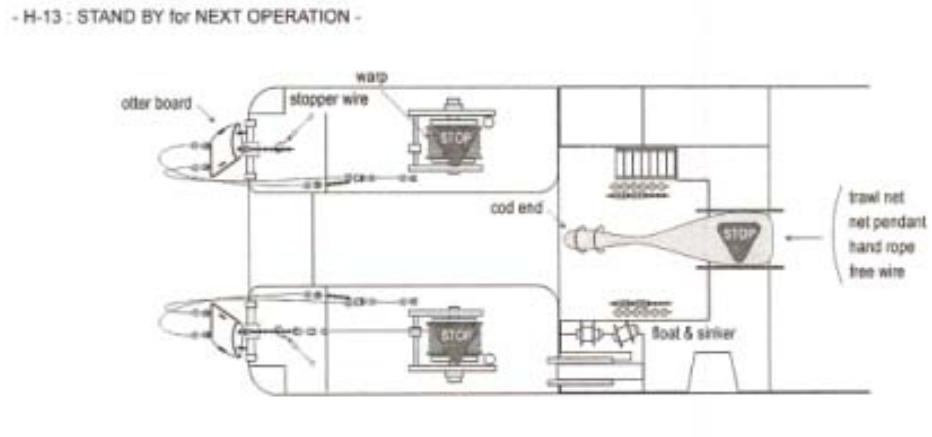


Figure 21 Hauling operation procedure step 13

5.4 Result of Midwater trawl fishing operation

There are twelve (12) fishing operations, conducted on the cruise. The positions are appeared by the chart and table. Detail of operation is present in the appendix

The operation on M.V.SEAFDEC2 is has limitation on instruments trouble, i.e. warp counter is out of order. Display is not showed the length of warp also speed of releasing rate. That make fishing operation is not able to carefully release the appropriated length and difficult setting trawl net to desired depth in particular shallow water area.

Net sensors always show error at the depth layer less than 30 m. Therefore fishing operations, where depth less than 50 m, are not able to obtain accuracy midwater trawl net setting. As well as fishing gear is danger to crash with sea bottom as happened at station No.2, No.3 and No.6

Operation No.1 and No2 is designed for sea trial and fishing gear arrangement target to enhance human capacity of deck crew and to maneuver practicing of trawl fishing operation. Regarding to the limited depth as 60 m. Length of paid out towing warp is 150 m.

Result is head line depth of 50 m. towing warp paid out is less than 20 m. sinking rope is different in regarding to the deployed of additional sinker. In case of additional sinker is fixed at lower net pendant, sinker line is deeper than 30 m but depth is decreased to 10-15 m while no sets of additional sinker are fixed. Regarding to the depth of fishing ground and fishing gear handling on the deck, midwater fishing operation is operated without sets of additional sinkers.

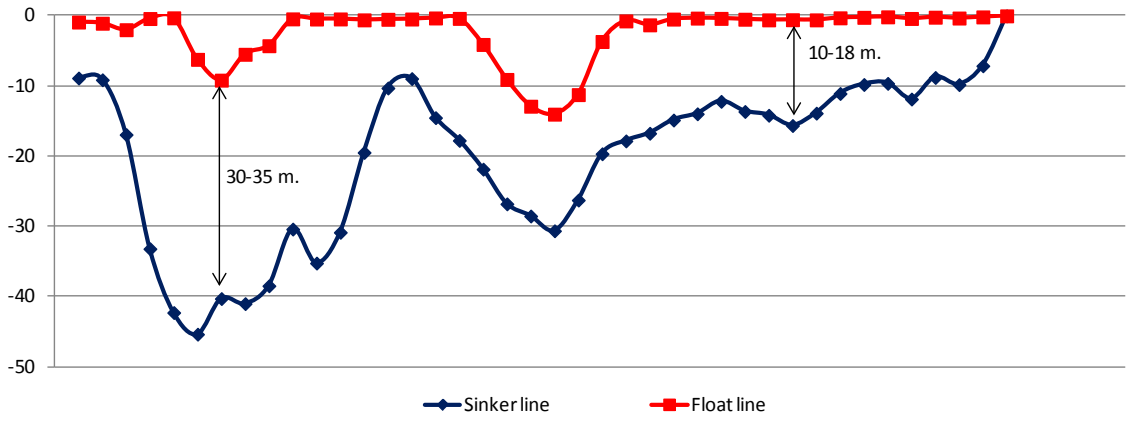


Figure 22 Sea trial operation with warp length 50 m.

5.4.1 Sea trial operation for 3 warp length

Sea trial on deployment of towing warp and fishing speed is operated by using 3 warp lengths, i.e. 50, 100 and 150 m respectively. Towing speed is used with 3.9-4.1 knot in regarding to the request of Viet Nam scientist.

Result shows that warp length 50 m, depth of head line is 16-17 m and depth of fishing line is between 30-31 m. Net opening is between 15-16 m. Warp length 100 can control the depth of head line is 30-31 m and depth of fishing line is between 39-40 m. Net opening is between 8-9 m. Warp 150 can control the depth of head line is 44-46 m and depth of fishing line is between 54-55 m. Net opening is between 10-11 m. (See figure)

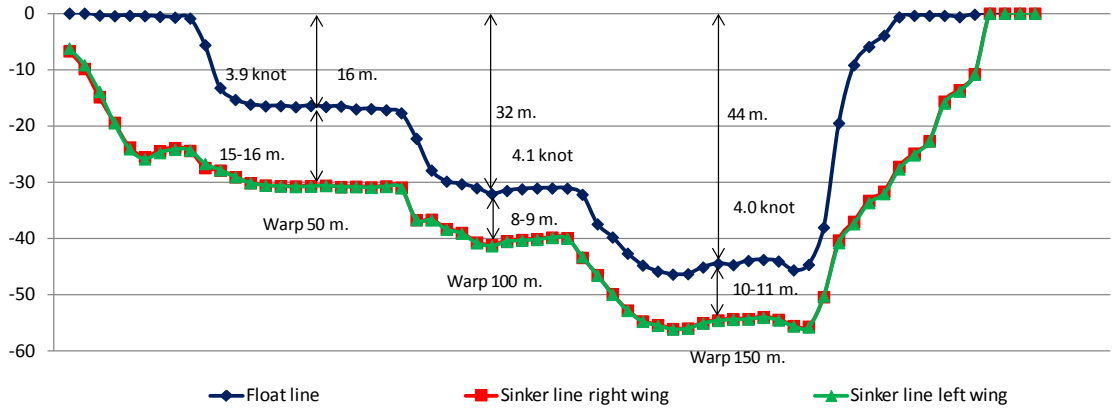


Figure 23 Sea trial operation for 3 warp length; 50 m, 100 m amd 150 m.

5.4.2 Net setting without additional floats

The first operation has conducted without additional float at head line. Sea depth is 94 m. Towing warp is paid out at 300 m in length for 40 minutes but shortened to 250 m after 40 minutes. Estimate the depth of Head line at first 40 minute is 85 m and fishing line is touched the bottom at 94 m. Therefore net opening at the first 40 minute is 6 meters. After 40 minute fishing line is above sea bottom so net opening is expanded to 11 m. Observed by catch result found bottom fishes e.g. *Prioacanthis* sp. and etc. Catch result presumes sinker line reach sea bottom.

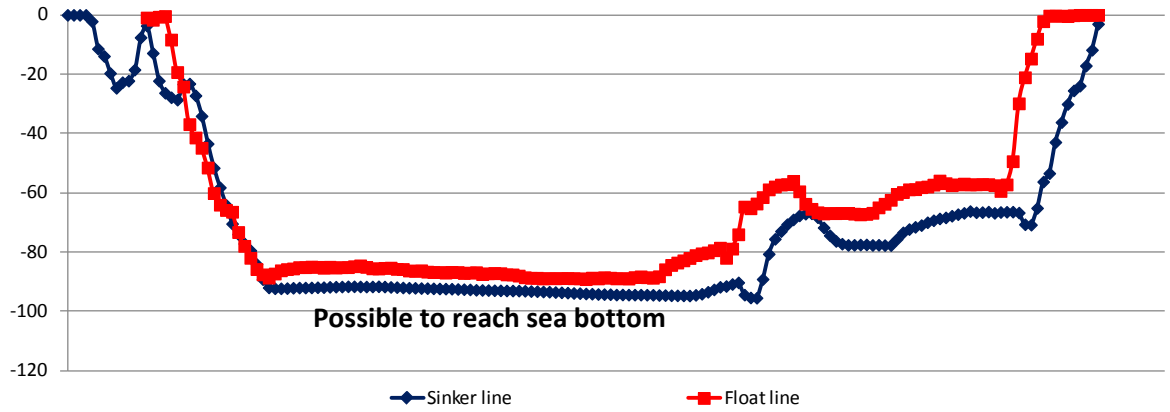


Figure 24 Net setting without additional floats

5.4.3 Net setting against the strong current

The second operation aims to investigate the net setting against the strong current. Regarding to current condition, 1.1 knot, SSW direction, setting net against current found that net opening is decrease from the regular opening of 10-11 m to 9 m (Figure).

It is observed that before hauling operation, vessel need to reduce speed to 1-2 knot to compensate with the hauling action. Trawl net in particular the fishing line is always descent 5-10 m in regard to speed of towing warp winch. By this reason, net setting to close sea bottom is caused accident of net get stuck with sea bottom in particular rocky of rough bottom structure (Circle Point).

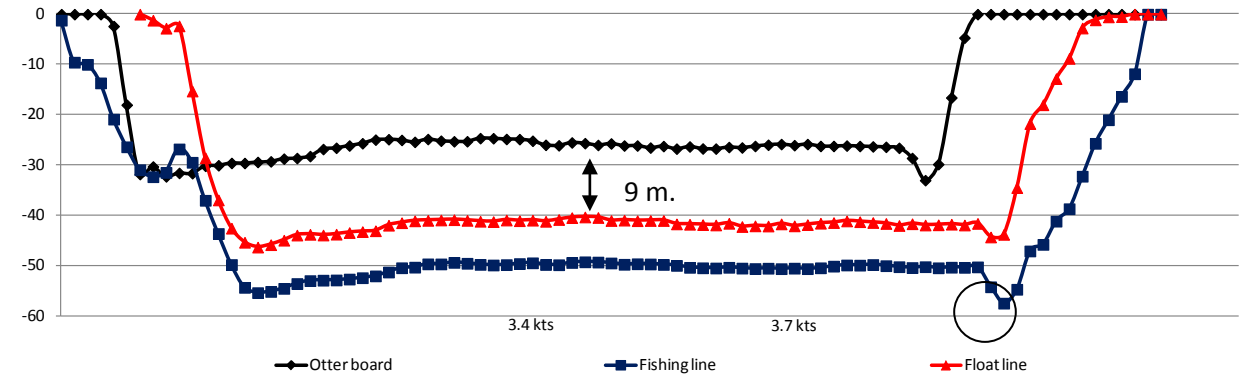


Figure 25 Net setting against the strong current

In case of net is affected trawling across current direction, towing lines are not in the point out with opposite angle between starboard towing block and port side towing block (See figure). Both towing warps intend to same direction depended on direction

of current. By this phenomenon, otter boards are not in same depth layer because angle attack is different by current force. The operation No. 9 shows different of otter board layer 3-12 m.

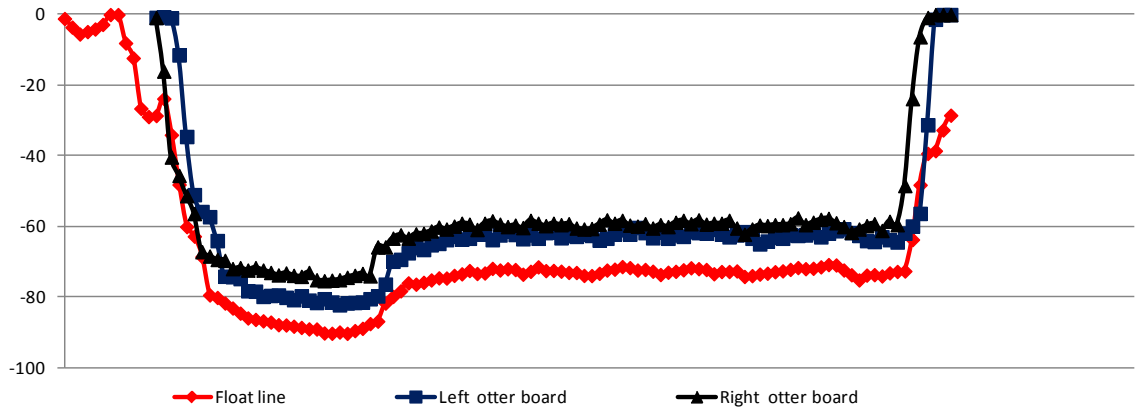


Figure 26 Net setting across the strong current

5.4.5 Net Setting by using otter board without additional weight

Result of setting midwater trawl net by otter board without additional weight is found the unsatisfied level of otter board. FAO (1990) refers that otter board level should be same level as net opening. The trial without additional show otter board is more than 10 m higher than head line. It is seem to effect of kite is make higher tension or dragging force at towing line than weight of otter board. (Lifting force by kite is more than sinking force) It is impact to angle attack and making net smaller net width.

The operation No. 3 and No.5 show the otter board setting without additional weight. Both of operations show otter board levels are higher than head rope approximately 10 m compare and more than center of net opening approximately 20 m.

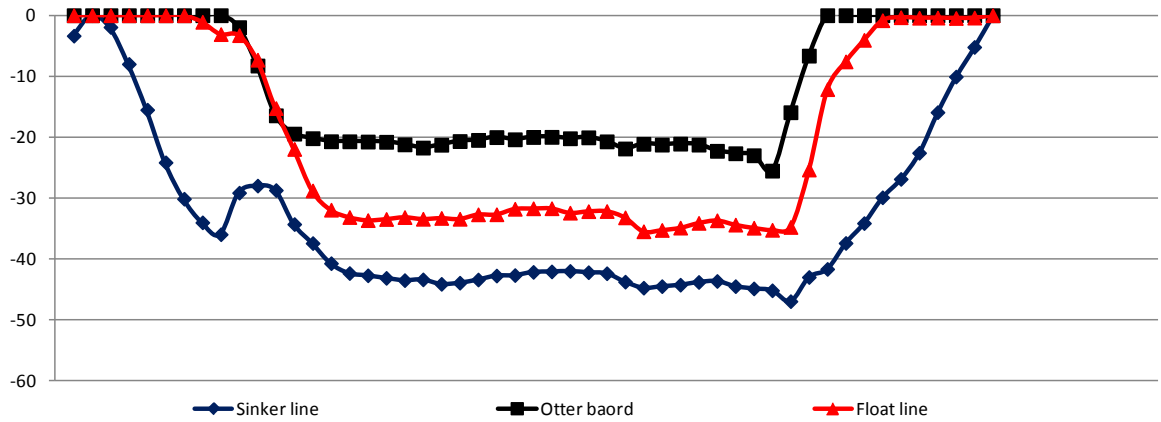


Figure 27 Net Setting by using otterboard without additional weight

5.4.6 Net setting net by using otter board with additional weight

Result of setting midwater trawl net, operation No.10 what conducted by using otterboard with additional weight shows the level of otter board is nearly center of net opening. Depth of Otterboard level is above the fishing line (ground rope) approximately 16 m, but lower than head line approximately 5 m. It is seem to effect of kite is closely to balance with weight of otter board. (Lifting force by kite is close to sinking force) correction!!

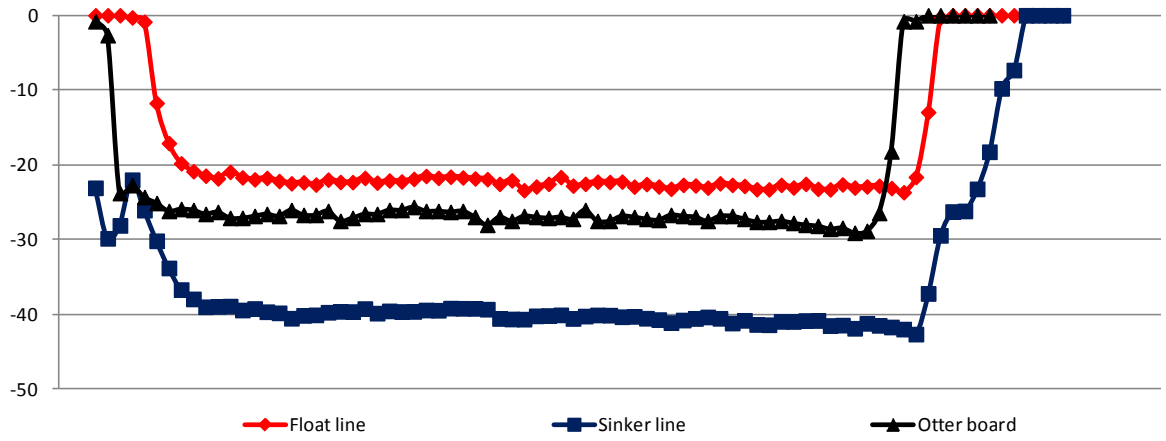


Figure 28 Net setting net by using otterboard with additional weight

5.4.7 Net setting without lifting force of kite

The operation without kite is set at operation No.3. Sea depth 127 m and depth of capture is targeted at 65-75 m. There is error on net sensors, consequence to towing warps are over paid out to 350 m. Regarding to depth data recorded by depth loggers, trawl net reaches sea bottom. Therefore result of the operating without kite is not able to recognize the significant different between operating with kite.

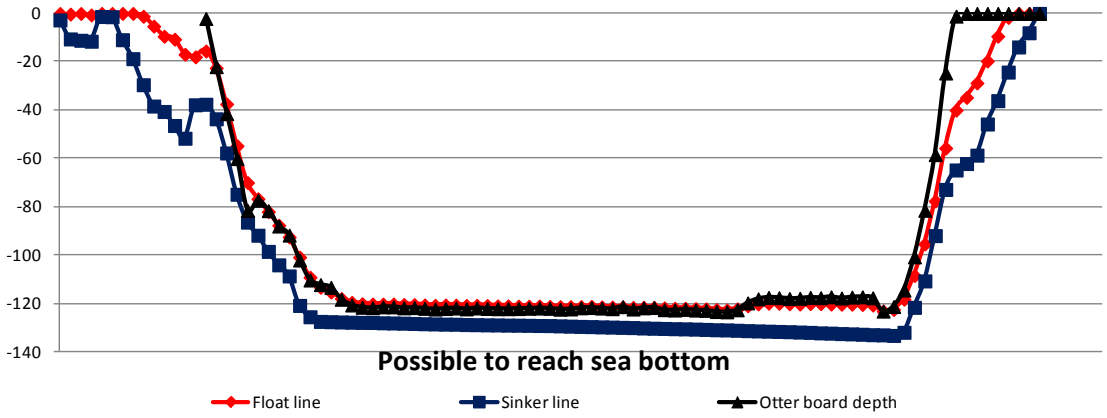


Figure 29 Net setting without lifting force of kite

Respect to the suggestion by Taito Seiko fishing technologists, if sea current on the fishing ground shows the unique in direction and speed, or less variation of the current condition, kite is applicable to control depth layer of trawl net. In case of Andaman Sea where current is variable with massive internal solitons, kite should be replaced by additional set of floats.

Current condition around Viet Nam Waters observed by Doppler current indicator, generally show variation by depth layer. Current of upper layer from 0-5 m always show same direction as wind direction. Current velocity is depended on wind, sometime up to 1.6 knot. The lower current layer, 50 m, is unique condition regarding to oceanic current. However current in Viet Nam Waters is always strong more than 1.0 knot but unique direction. Therefore kite is possible to perform during operation in Viet Nam Waters.

6. Conclusion and Recommendation

1) To investigate fishing efficiency, midwater trawl performance and pelagic resources abundance, Real-time depth sensors, e.g. net sonde, net recording etc., and depth logger is essential to record depth of capture and vertical opening.eration.

2) Net Sonde installed with midwater trawl net is only real-time depth sensor used for this cruise. The accuracy is found error at the depth less than 20 m. As well as trawl eyes sensor and wing net sensor found malfunction. All data of net depth is recorded by depth logger, attached at ground rope and float rope. During the trip, 2 depth loggers are lost because ground rope is dragged on sea bottom. Recommend to prepare accuracy net recorder and wing net sensor for midwater trawl operations.

3) Weather condition is one of the major hindrances affected to fishing operations during the cruise survey. Wind force level five (5) makes trouble the vessel maneuvering and danger to deck crew. It is found whist the vessel drifts more than 2 knot or wind force is stage 5 (25-40 km/hr). That is impossible for setting the net because speed of vessel during shooting net cannot be controlled. If shooting operation is success, strong wind directly affects to towing speed both follow wind and against to wind direction.

4) Regarding to weather and sea condition, speed of vessel is not able to operate more than 4 knot. That made midwater net performance is less than the sea trial in year 2004.

5) Setting across strong wind or current cause otterboard layer is different between port and starboard as well as the dangerous to otter board turn up side down during shooting operation/ Setting across wind and current is dangerous to deck crew during setting and hauling net because trawler can not keep ship heading constant.

6) Refer to sea trial undertaken by Taito Seiko Co., LTD. Japan, midwater trawl net vertical opening is approximately 30 m. it is similar to operate whist additional sinkers are attached at lower net pendants. The operations without additional sinkers, however, are found 8-15 m vertical opening.

7) Refer to sea trial undertaken by Taito Seiko Co., LTD. Japan, midwater trawl net spread is approximately 20 m. Regard to the trouble of distance sensors, data of wing spread is not able to obtain during this experiment.

8) Depth is important for safety operation of MV SEAFDEC2 should not shallower that 40 m. However bottom characteristic need to investigate in the shallow water fishing ground before fishing operation. It is noted that net setting on the shallow fishing ground used very short towing warp and fish school may be frightened and defragged by vessel or propeller noise. There is possible to zero catch whist operate in shallow

water fishing ground. High opening bottom trawl is option for area what sea depth less than 40 m.

9) Modification of midwater trawl net for more convenient for operation e.g. reduce scale of net, change some lighter weight material should be priority carried out.

10) Additional weight should be fixed at otterboard. Result of experiment show the similar position as experiment undertaken by Taito Seiko Co., LTD. Japan as otterboard depth is 5 m lover than float line.

11) In order to obtain the accuracy and performance skill of deck crew, midwater trawling should be frequency operated.

7. Acknowledgment

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9. Appendix

9.1 Result of midwater trawl fishing trial on 29-30 January 2004 for M.V.SEAFDEC2 reported by Taito Seiko Co., LTD.

JAPAN. Taito Seiko reported that midwater trawl provided by Taito Seiko is safely and reliable by M.V.SEAFDC2. It is applicable to operate with underwater TV camera which was set at center of head rope and confirmed by sea trial to record around the part of net mouth. Sea trial show warp control is well function.

1. Sea trial condition

1.1 Sea trial Details are composed with operation with warp length 200 m, 300 m and 400 m., at towing speed 3.0, 4.0 and 5.0 m.

1.2 Ship speed is recorded by GPS and Doppler log

1.3 Position of fishing gear, depth of head rope, fishing line, net height and net width is recorded by Scanmar sensors.

1.4 Depth of otterboards (both port and starboard side), head rope and fishing line is recorded by depth loggers.

(a) (b)

Figure 1 Depth sensors (a) Scanmar depth sensor (b) Depth logger

1.5 Warp angle is measure at towing block and depth of otter board (both port and starboard side) is estimated by measuring the interval of towing block and the warp interval behind 1 m of towing block. Interval of otterboards is estimated.

1.6 Warp tension at port side is estimated by Hydraulic tension meter of three-role type. Warp tension at starboard side is estimated by spring scale.

2. Result of fishing operation

2.1 Different from trawl model experiment

a) Height of net and head rope at range of speed 3.0-5.0 knots

Model	26.5 m – 21.5 m.
Trial	33 m. -28 m. (Approximately height 7 m.)
Possible cause	a. Buoyancy and Sinking force were grater.
	b. Lifting force of kite is greater.
	c. Otterboard opening force is lower
Countermeasures	a. Adjustment of front floats and front weights (in particular the front floats)
	b. Adjustment kite angle, by shortening chain length on the wing net
	c. Adjust otterboard angle to make attach angle grater.

b) Depth at center of the net mouth (at head rope) relative to the otter board depth at range of speed 3.0-5.0 knots

Model	About 10 m deeper
Trial	About 10 m at low speed and about 5 m. shallower 5 m at high speed
Possible cause	a. Lift of kite is greater than sinking force.
	b. Wing net buoyancy further lift the net.
Countermeasures	a. Mainly, adjust front floats
	b. Auxiliary, adjust kite angle.
	c. Adjust net pendant: Same upper and lower rope (make 0 m different) Make lower rope longer, so that net come lower. Lower rope of the model was by 60 cm shorter.

2.2 Different from calculated data

a) Otterboards depth when warp pay out at 400 m and speed 4.5-5 knot.

Calculation	90 - 69 m.
Trial	47 - 20 m and shallow water is approximately 50 m
Possible cause	a. Error on ship speed measurement.
	b. Otterboard has been lightweight relative to the net resistance
	c. Effect of kite lifting force.
Countermeasures	a. Otterboard weight for shallow-water (50-100 m) is 500 kg.
	b. Otterboard weight for midwater (150 m) is 600 kg.
	c. Lower rope of the pendant to be made longer.
	d. Adjust the kite lift.

3. Conclusion of fishing trial

3.1 Speed

Instruction by the shipyard after testing, measured speed is checked by multiply the log speed by 1.34. The log speed is record 1 time within measuring time under certain condition.

3.2 The position of fishing gear

The depth change of fishing gear is shown in Figure1 and Figure2. This data was taken by the memory type depth meter.

The position of fishing gear is also investigated by Scanmar sensors during testing but net height is not taken. The indication of net depth (Float line depth) is neither stable. It seemed to be impossible to adapt the data taken by it. Only the indication of wing interval is clear and stable.

Estimate depth of otterboard taken by protector is big different from the data taken by depth meter.

3.3 Net height

The net height is 28-33 m different form the design of bet height 20 m. The lifting power of kite is seem to be too strong. It is adjust to the pan of net height by the combination of wing floats sinkers and the kite.

3.4 Wing interval

Wing interval is kept 20 m as design.

3.5 Depth of otterboard

Under consideration of depth of testing ground, all the additional weight pieces of otterboards are removed off. And the lifting power of kite is estimated too big compare to calculation. Therefore the depth of fishing gear was tow in shallow water. This problem is solved by adding weights to otterboards. The weight of otterboards is considered to make two modes of 500 kg and 600 kg underwater. (Referred to attachment of result of midwater trawl trial and relationship between warp length and head line depth; table 2 and 3)

3.6 Warp tension and fishing gear resistance

It seemed to be useful to take of tension measuring by the scale but when tension becomes bigger, the different of figure between scale and hydraulic tension meter is too much. Data taken by hydraulic tension meter is adopted at port side.

Table 1 shows relationship of speed and fishing gear. The resistance of fishing gear is calculated by the warp tension and the average depth of otterboard. (The horizontal expansion is not considered) The minimum resistance is 2.62 ton-force (2.9 knots, warp length 200 m.) and maximum is 6.75 ton-force (5.1 knots, warp length 400 m.) These figures show as plan one.

(a) (b)

Figure 2 Warp tension meter (a) Warp tension rollers (b) Warp Tension analog display

Result of experiment in Japan

Table 1 Relationship between total dragging force and ship speed

No	Propeller Pitch (Degree)	Power (kW)	Warp (m)	Speed (kt)			Depth of otterboard (m)		Tension (kgf)	Total dragging force (kgf)
				Log	GPS	Revised	Starboard	Port		
1	10	155	200	2.2	2.8	2.9	58	61	1370	2620
2	12	265	200	2.7	3.3	3.6	31	33	1870	3692
3	16	-	200	-	4.0		17	19	-	-
4	9	210	300	2.2	3.3	2.9	89	92	1470	2807
5	13	295	300	2.6	4.4	3.5	56	59	1870	3672
6	16	368	300	3.1	4.6	4.2	28	32	2420	4816
7	9	185	400	2.2	3.1	2.9	118	122	1520	2904
8	13	315	400	2.7	3.9	3.6	73	76	1970	3872
9	16	410	400	3.0	4.4	4.0	46	49	2500	4965
10	18	-	400	3.8	5.1	5.1	18	21	3380	6752
11	21	750	400	3.8	4.6	5.1	19	23	3380	6751

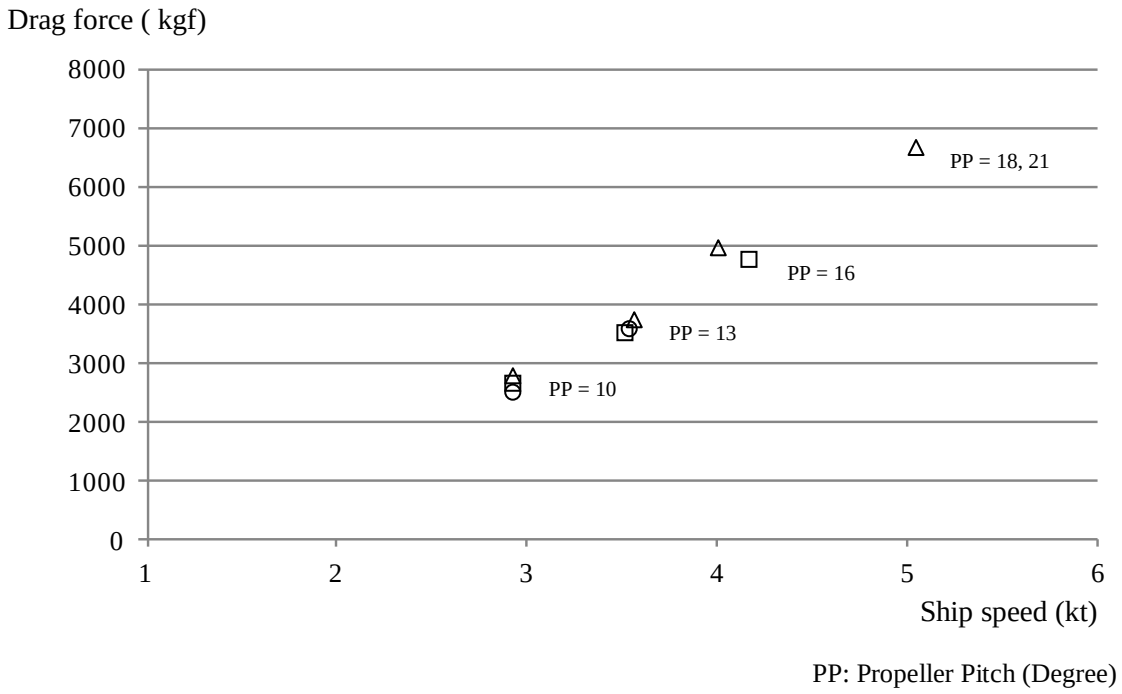


Figure 3 Relationship between total dragging force and ship speed

Table 2 Relationship between depth of head rope and warp length (OB dimension: 0.75 x 1.65 adjusted weight 500 kg)

Towing 4.5 knot

Warp length	100	150	200	250	300	350	400	450	500	550	600	650	700	750	800	850
Depth of head rope	2	10	19	29	39	51	63	76	90	105	120	135	152	168	186	203
Depth of OB	12	20	29	39	49	61	73	86	100	115	130	145	162	178	196	213
Distance between OB	37	46	53	59	64	67	70	73	75	77	78	80	81	82	83	83
Total drag (kgf)	5137	5161	5186	5215	5240	5271	5306	5343	5384	5429	5477	5528	5583	5641	5702	5766
Total drag (kN)	50.4	50.6	50.9	51.1	51.4	51.7	52	52.4	52.8	53.2	53.7	54.2	54.8	55.3	55.9	56.5
Distance between wing	14.6	18.4	21.3	23.5	25.3	26.7	27.9	28.9	29.8	30.5	31.1	31.7	32.1	32.5	32.9	33.2

Towing 5 knot

Warp length	100	150	200	250	300	350	400	450	500	550	600	650	700	750	800	850	900	950	1000	1050
Depth of head rope	-4	0	5	11	18	25	34	43	53	64	75	87	100	113	126	140	155	170	185	201
Depth of OB	6	10	15	21	28	35	44	53	63	74	85	97	110	123	136	150	165	180	195	211
Distance between OB	37	47	54	60	65	69	72	74	77	78	80	81	83	84	85	86	86	87	88	88
Total drag (kgf)	6263	6282	6298	6315	6332	6350	6371	6394	6420	6448	6480	6515	6553	6594	6639	6687	6738	6792	6849	6909
Total drag (kN)	61.4	61.6	61.8	61.9	62.1	62.3	62.5	62.7	63.0	63.2	63.5	63.9	64.3	64.7	65.1	65.6	66.1	66.6	67.2	67.8
Distance between wing	14.8	48.7	21.6	23.9	25.8	27.3	28.5	29.6	30.5	31.2	31.9	32.4	32.9	33.4	33.8	34.1	34.4	34.7	35.0	35.2

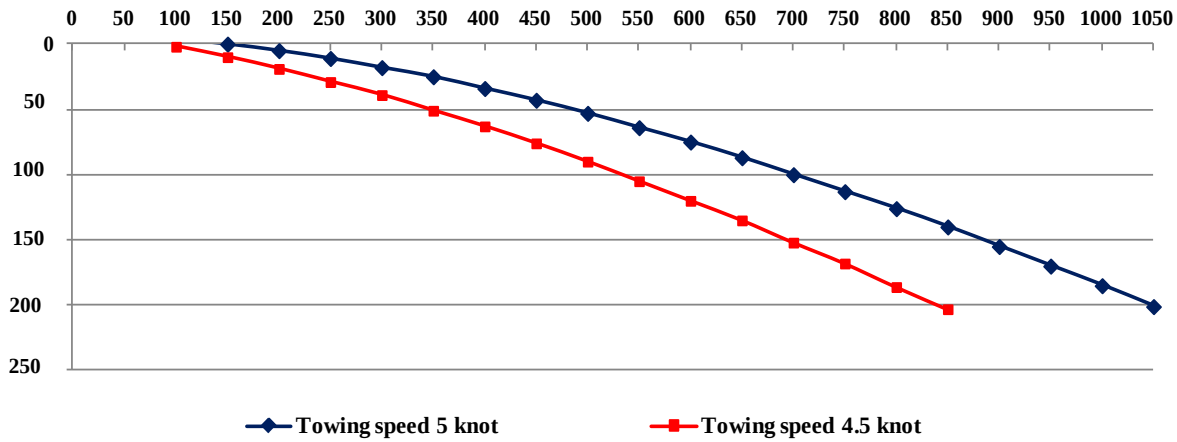


Figure 4 Relationship between depth of head rope and warp length (OB dimension: 0.75 x 1.65 adjusted weight 500 kg)

Table 3 Relationship between depth of head rope and warp length (OB dimension: 0.75 x 1.65 weight 600 kg)

Towing 4.5 knot

Warp length	100	150	200	250	300	350	400	450	500	550	600	650	700	750	800	850	900	950	1000
Depth of head rope	16	30	45	61	77	94	112	130	149	167	187	206	226	246	267	288	3.8	330	351
Depth of OB	26	40	55	71	87	104	122	140	159	177	197	216	236	256	277	298	318	340	361
Distance between OB	36	45	53	58	62	66	69	71	74	75	77	78	79	80	81	82	83	84	84
Total drag (kgf)	5157	5213	5271	5333	5397	5464	5535	5609	5686	5766	5849	5934	6022	6112	6205	6299	6395	6493	6593
Total drag (kN)	50.6	51.1	51.7	52.3	52.9	53.6	54.3	55.0	55.8	56.5	57.4	57.4	57.4	57.4	57.4	57.4	57.4	57.4	57.4
Distance between wing	14.3	18.1	20.9	23.1	24.9	26.3	27.5	28.4	29.3	30.0	30.6	31.1	31.6	32.0	32.4	32.7	33.0	33.3	33.5

Towing 5 knot

Warp length	100	150	200	250	300	350	400	450	500	550	600	650	700	750	800	850	900	950	1000
Depth of head rope	10	21	33	46	59	73	87	102	118	134	150	167	184	201	219	237	255	274	292
Depth of OB	20	31	43	56	69	83	97	112	128	144	160	177	194	211	229	247	265	284	302
Distance between OB	37	47	54	60	64	68	71	74	76	78	79	81	82	83	84	85	86	87	87
Total drag (kgf)	6521	6300	6350	6401	6455	6512	6592	6636	6702	6772	6848	6992	7001	7083	7168	7255	7344	7436	7530
Total drag (kN)	61.3	61.8	62.3	62.8	63.3	63.9	64.5	65.1	65.7	66.4	67.1	67.9	68.7	65.9	70.3	71.1	72.0	72.9	73.8
Distance between wing	14.7	18.6	21.5	23.8	25.6	27.1	28.3	29.4	30.2	31.0	31.6	32.2	32.7	33.1	33.5	33.9	34.2	34.4	34.7

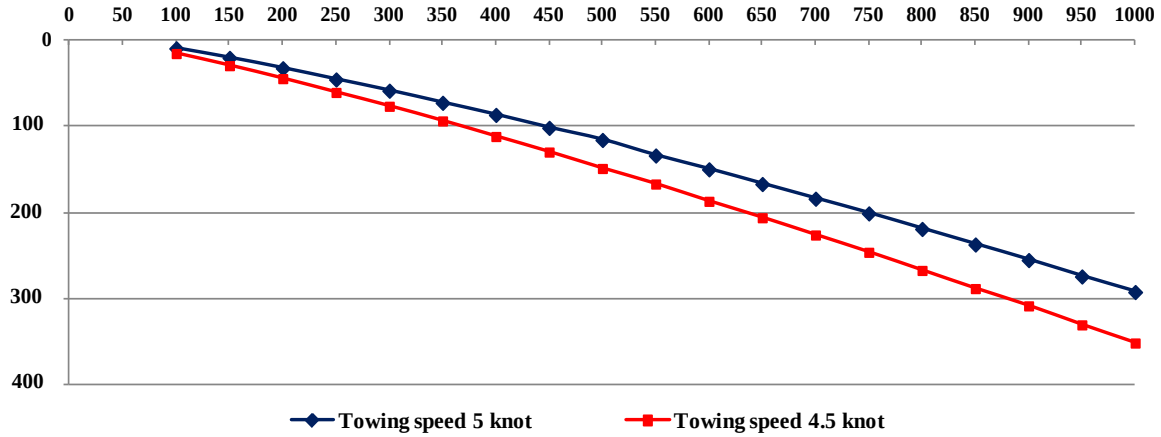


Figure 5 Relationship between depth of head rope and warp length (OB dimension: 0.75 x 1.65 weight 600 kg)

7.2 M.V. SEAFDEC2 ship particular

Main Dimensions

Length Overall (Loa)	33.24 m
Length between perpendiculars (Lbp)	27.0 m
Breadth, Molded (B)	7.2 m
Depth, Molded to upper deck (D)	3.0 m
Design draft, Molded (D)	2.7 m

Gross Tonnage and Capacity

Gross tonnage	211 t (international)
Fuel oil tank (100%)	55 m^3
Fresh water tank (100%)	10 m^3
Washing fresh water tank (100%)	3 m^3
Fish hold (bale)	20 m^3

Machinery

Main Engine Output	1000 Ps	1 Unit
Electric Generator	120 Kva	2 Unit

Speed and endurance

Maximum speed at sea trial	12.5 knot
Service speed	12.0 knot
Fuel oil consumption (24 hours)	3.83 kl/day
Endurance about	39,000 nautical miles

Complement

Crew	15 persons
Instructor/scientist/participants	22 persons
Total	37 persons

Nautical and electronics equipment

Magnetic compass	1	Set
Gyro Compass and Auto Pilot	1	Set
GPS navigator	2	Sets
Radar	2	Sets
Digital sea water/Ambient thermometer	1	Set
Direction finder	1	Set
Color fish finder	1	Set
Scanning sonar	1	Set
Trawl monitor	1	Set
Underwater television	1	Set

Fishing gear

Bottom trawl

Midwater trawl

Pelagic longline

Bottom longline

Drifting gillnet

Automatic squid jigging

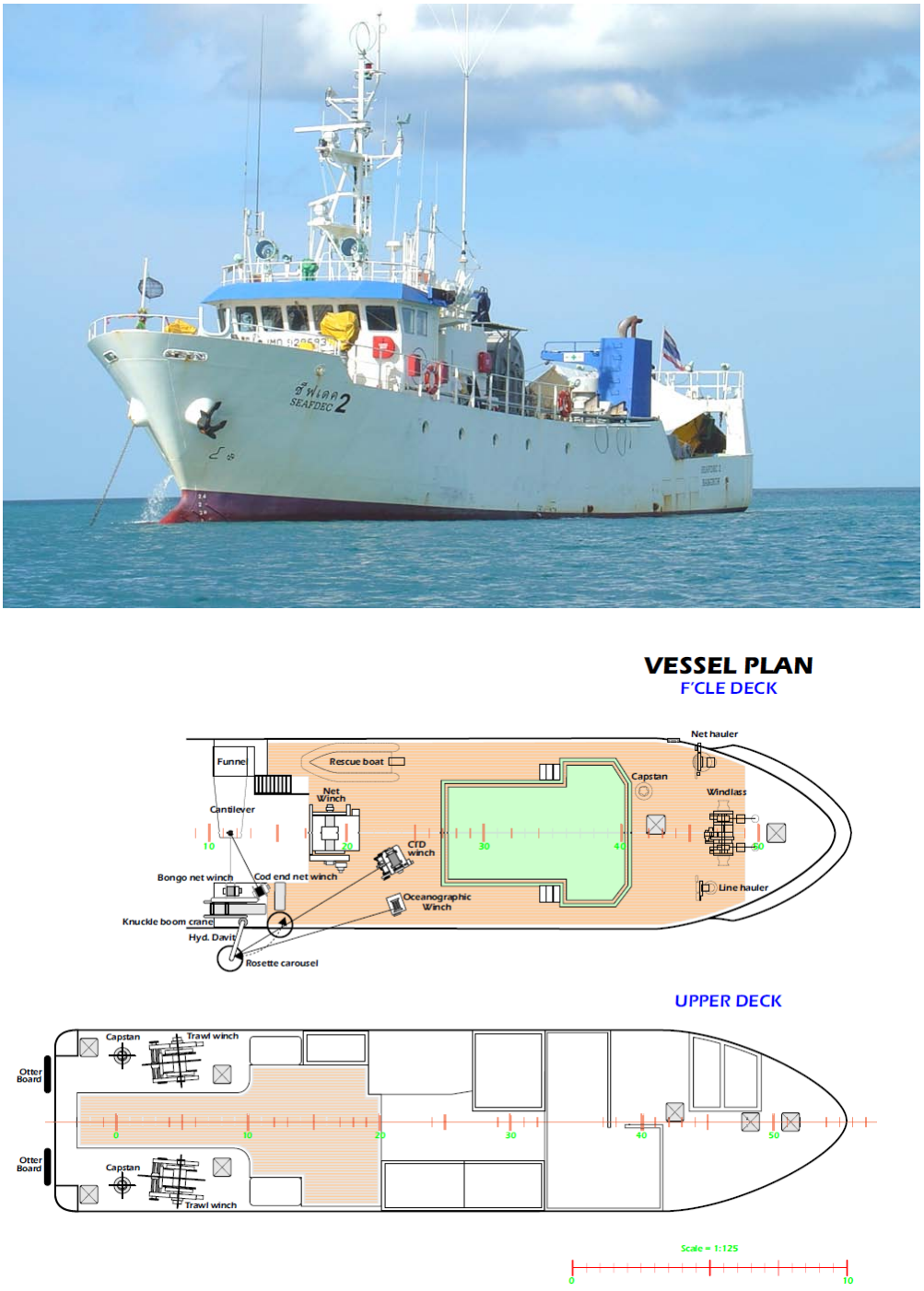
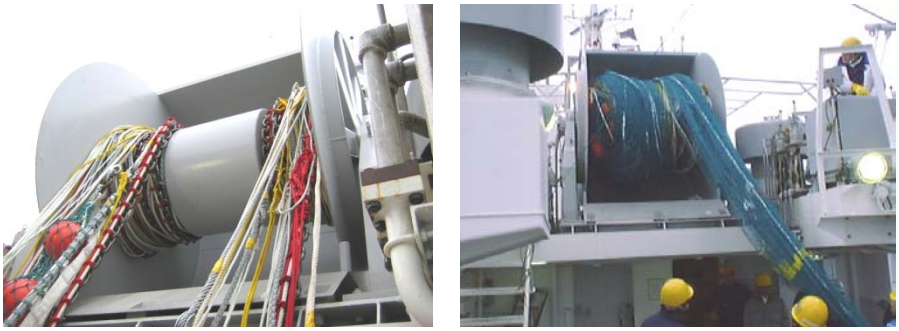


Figure 6 M.V. SEAFDEC2



(a)

(b)

(c) (d) (e)

Figure 7 Trawl deck machineries of M.V. SEAFDEC; (a) Net drum (b) Towing warp winch (c) Towing block (d) Winch control system and (e) Digital towing warp meter